From the Author.

DIARY

OF A

MAGNETIC SURVEY

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DIARY

OF A

MAGNETIC SURVEY

OF A PORTION OF THE

DOMINION OF CANADA

CHIEFLY IN THE

NORTH-WESTERN TERRITORIES

EXECUTED IN THE YEARS 1842–1844

BY

LIEUTENANT LEFROY, R.A.

NOW

GENERAL SIR J. H. LEFROY, C.B., K.C.M.G., F.R.S., &c.

WITH MAPS

LONDON

LONGMANS, GREEN, AND CO.

1883

PREFACE.

1. The renewed attention directed to the distribution and periodical changes of the Earth's Magnetism in the North Polar region, suggests an endeavour on my part to present the observations of my Magnetical Survey of 1843–4 with fuller explanation, and in a form more convenient for reference than that in which they were originally published.[1] It is true that they did not actually enter the Arctic Circle, but they touched the confines of it at Fort Good Hope, on Mackenzie's River, and being still the principal authority for the received position of the focus or pole of greatest magnetic intensity, as well as for the lines of equal magnetic force, equal inclination, and equal variation, over a large part of the continent of North America, it is certain that whenever they come to be repeated, the Observer of the future will inquire for particulars not contained in, and not suitable for, the 'Philosophical Transactions.'

I have gone into many details which may seem to some persons unnecessary; similar information respecting the personal experience of previous observers would, however, have been of much use to me, and I do not think that they will be found superfluous by any future American traveller who may give his attention to the same subject.

2. The following letters and minutes of the Council of the Royal Society show in what manner this particular survey originated, and what were the views of its author, the late General Sir Edward Sabine, R.A.

[1] Sabine's Contributions to Terrestrial Magnetism, No. VII. *Philosophical Transactions*, 1846, p. 237; *id.* No. XIII. *Phil. Trans.* 1872, p. 353.

Correspondence relating to the Magnetic Survey of the British Possessions in North America.

January 7, 1841.—Letters were read from Major Sabine to Sir John Herschel, Chairman of the Committee of Physics, on the subject of a Magnetic Survey of the British possessions in North America, and also letters on the same subject from Sir John Herschel, Dr. Peacock, Sir Hew Ross, Deputy Adjutant-General of the Royal Artillery, and Lieut. Riddell, R.A., Director of the Magnetic Observatory at Toronto, in Canada.

'Resolved,—That these letters be laid before the Council, with a strong recommendation from this Committee, that the President and Council will take the proper steps to recommend to the Government the execution of the proposed survey.'

Letters.

'London, November 25, 1840.

(1). 'My dear Sir,—It is quite unnecessary that I should make any preliminary remarks on the importance of a Magnetic Survey of the British possessions in North America to *you*, who have yourself, in the "Quarterly Review," placed in so clear a light the value of such surveys in general, and of the one in question in particular; nor need I dwell on the advantages of making the survey whilst there is a magnetic observatory in Canada, to serve as a primary station for reference and comparison.

'The object of my present letter is to propose a definite plan for its performance, which I address to you, as Chairman of the Committee of Physics of the Royal Society, in which the details might be beneficially discussed, and from whence its recommendation might with propriety emanate.

'1. The strength of the Canadian observatory to be increased by one officer and one non-commissioned officer for three years; and an addition to be made to the instruments of

One inclination instrument with two dipping and two intensity needles.
One transportable magnetometer with unifilar and bifilar suspensions.
One sextant and artificial horizon.
Two portable stands.

'2. I have ascertained by personal communication with the Chairman of the Hudson's Bay Company, that for a public undertaking of this nature, the Company is ready to furnish gratuitous canoe conveyance in the territories belonging to them; and from inquiries that I have made I have reason to believe that two summers thus occupied would supply ample materials for the countries north of the Canadian provinces, within limits of convenient access. For excursions within the Canadian provinces, and for other small contingent expenses, I consider that 50*l.* a year for each of the three years would be sufficient, which should be payable in the same manner as the observatory contingent allowance, on the certificate of the Director of the Observatory.

'3. Lieut. Younghusband, of the Royal Artillery, has been acting for some months, with the permission of the Master-General of the Ordnance, as a gratuitous assistant to Lieut. Riddell at the Toronto Observatory, with a view of qualifying himself for this undertaking. The zeal he has evidenced, and the very favourable manner in which Lieut. Riddell speaks of him in all respects, show him to be a highly eligible person, and his presence on the spot is an advantage in saving the expense of a passage to Canada.

'4. The whole expenditure contemplated for this undertaking would be nearly as follows:—

For instruments . .		£130			
One officer's extra pay, annual		183	For 3 years		£549
One non-commissioned officer's extra pay .	,,	27	,,	,,	81
Contingent . .	,,	50	,,	,,	150
					780
		Instruments . .			130
		Total . .			£910

Total 910*l.* in three years, or in round numbers 300*l.* a year for three years.

'Believe me, &c.

'EDWARD SABINE.

'SIR JOHN HERSCHEL, Bart.'

'Collingwood, November 27, 1840.

(2). 'DEAR SIR,—As regards the proposition in your letter, as you have therein connected my name with my opinions as stated in the "Quarterly Review" (to which I do not in the least object, as it was never my desire or wish to regard that article as anonymous, and as there is now an obvious reason for avowing it), in which I have distinctly advocated the very point in question, and supported it by arguments to which I can add nothing either in the way of novelty or force, but mere reiteration, I could not, in fact, by my personal attendance do more than I have already done. Only I may add, that I have as yet seen no ground to weaken that opinion, but that on the contrary, the more I reflect on the desirableness of procuring Magnetic Surveys of the Colonies, the more apparent it seems.

'The programme of the operation as regards the personal and material, as stated in your proposal, appears perfectly calculated to meet the requisites of the case, and I have no hesitation in conveying through you to the Committee my own entire approbation and concurrence in its coming before the Council, recommended by them as a proper object for application to Government. In the recommendation of such objects for public support, the Royal Society is only performing its duty to the country and to science. It is for the Government to decide what portion of the national resources can be afforded for scientific purposes. All that we have to look to is that the objects we do recommend be really great and worthy ones, and that the means we propose be well adapted to the end.

'Believe me, &c.

'J. F. W. Herschel.

'Major Sabine.'

'Woolwich, November 26, 1840.

(3). 'My dear Sabine,—I do not see the least objection to the employment of Lieut. Younghusband and a non-commissioned officer of the Artillery to assist in carrying out the Magnetic Survey in British North America, should your proposal receive the sanction of the Master-General. Lieut. Younghusband is a very promising officer, and I shall be very glad if he is permitted to continue on the service on which he is now employed.

'Believe me, &c.

'Hew Ross.

'Major Sabine, &c.'

'Toronto, November 25, 1840.

(4). 'I write a few lines to thank you for your proposals as to the survey of this part of the world. They embrace, I think, all that can be wished for, or required from the Government, *i.e.*—

1. Lieut. Younghusband and an additional gunner to be attached to the observatory for three years.
2. Instruments to be furnished, value 130*l.*
3. 50*l.* a year for three years on contingent account for travelling expenses.
4. An arrangement to be made with the Hudson's Bay Company to convey an officer and assistant on two summer trips, or three if necessary.

'C. J. B. Riddell.'

Minute of Council.

(5). Jan. 7, 1841.—Resolved,—That the recommendation of the Committee of Physics contained in this resolution be adopted, and that the President be requested to confer with the Chancellor of the Exchequer and the Master-General of the Ordnance on the subject.

3. The Marquis of Northampton, President of the Royal Society, wrote accordingly to the Treasury on January 10, 1841, and their Lordships agreed to meet the estimated expense amounting to 910*l.*, with the understanding that, as stated by him, gratuitous canoe conveyance would be provided by the Hudson's Bay Company in the territories belonging to them.[1]

4. The foregoing plans, however, were not exactly carried out. Lieutenant, now Major-General, C. J. B. Riddell, C.B., was invalided home from Canada in 1841, and became Major Sabine's assistant; Lieutenant, now Lieutenant-General, C. Younghusband, C.B., then serving in Canada, was placed in temporary charge of the observatory at Toronto; and the permanent charge, with the magnetic survey annexed, was offered to me. Leaving St. Helena in February 1842, I returned to England. Part of the following month of June was passed with the late Mr. Robert Weare Fox at his residence at Penjerrick, near Falmouth, for purposes of instruction in the manipulation of his Dip circle, and I left England for Canada on July 20, in the *Prince Regent* transport, which took forty-two days to reach Quebec. The Magnetic Variation and the Dip were observed daily on the voyage. The latter also on the voyage in the *Northumberland*, Indiaman, from St. Helena to England.[2]

In making the offer, in 1841, of 'gratuitous canoe conveyance' (*ante*, p. vi), the Hudson's Bay Company had no idea of saddling itself with a heavy expense. The understanding come to between the then Governor of the Company and Lieut.-Colonel Sabine, the one knowing little of the requirements of a scientific traveller and the other even less of the peculiar system of the Company's internal communications, proved to involve on both sides a great deal of misunderstanding, as shortly appeared by the subjoined letter of instructions issued by Sir George Simpson, who arrived at Montreal in April, to the Company's officers. In it he directed accounts to be opened and expenses to be charged against the Royal Society. The Council had not anticipated or provided for any such charges,

[1] *See* Treasury Letter, November 13, 1847.

[2] *See* Sabine's Contributions, No. IX. *Phil. Trans.* 1849, and No. XIII. *Phil. Trans.* 1872.

and when about two years later a bill amounting to 1,277*l.* was presented, which did not include any charge for my personal entertainment, a difficulty occurred over it. When these instructions were communicated to me, I lost no time in calling Lieut.-Colonel Sabine's attention to the subject, and then dismissed it from my mind. The justice of the claim was ultimately admitted, and a Treasury grant was made which satisfied the Company.

5. Letter from Mr. Trevelyan, addressed to the President of the Royal Society.

'Treasury Chambers, November 13, 1847.

'My Lord,—The Lords Commissioners of Her Majesty's Treasury having had before them the memorial and documents enclosed in your Lordship's letter of the 30th ultimo, relating to the charges of the Hudson's Bay Company in regard to the Magnetic Survey in North America:

'I am commanded to state to your Lordship that My Lords regret the misunderstanding which has occurred in regard to the expense of this expedition.

'In the paper transmitted with your Lordship's letter of the 10th January, 1841, it was distinctly stated that the whole expenditure contemplated for the undertaking was 910*l.*, and that gratuitous canoe conveyance would be provided by the Hudson's Bay Company in the territories belonging to them.

'Upon this statement the consent of this Board was given to the proposed expenditure, and My Lords were by no means prepared for the present demand upon the public purse, amounting to a further sum of 1,277*l.* 3*s.* 5*d.*

'It appears, however, that the greater part of this expense has been occasioned by a departure from the original plan of the expedition, and that the extension of the survey has been of considerable value and importance in a national point of view, and it might be reasonably expected that the Government should reimburse to the Hudson's Bay Company the expenses incurred by them beyond the amount originally contemplated. There is some difficulty in ascertaining the exact amount of the extra expense incurred, but it would appear from Capt. Lefroy's statement that it cannot have amounted to the whole sum mentioned, viz. 1,277*l.* 3*s.* 5*d.*

'Upon fully considering the whole of the correspondence, My Lords are of opinion that 850*l.* will reimburse to the Company all the expenses on account of which they may have a claim upon the public, and My Lords will in the ensuing Session submit an estimate to Parliament for this amount.

'In addition to this sum of 850*l.* there is a charge for clothing, &c.

supplied to Captain Lefroy, which that gentleman will repay to the Company through his agents, making the whole amount to be replaced to the funds of the Hudson's Bay Company on this account 885*l.* 5*s.*

'I have the honour to be, &c.

'C. N. TREVELYAN.'

'THE PRESIDENT OF THE ROYAL SOCIETY,
Somerset House.'

6. The proverbial saying *Les absents ont toujours tort,* was exemplified on this occasion; the 'departure from the original plan of the expedition' was supposed to be due to the zeal, meritorious perhaps, but indiscreet, of the executive officer, and the fact that every step was authorised and approved did not receive the prominence which he thought that justice required. The following extract from a letter from Lieut.-Colonel Sabine's assistant traces the misunderstanding to its source.

'Woolwich, March 3, 1845.

'Your early letters, *en route* outwards, mentioned that Sir George Simpson had directed the expenses of the Survey to be charged to a separate account to the Royal Society. This Colonel Sabine and I talked over at the time; but it appeared so impossible after the correspondence that had passed (*vide* the printed letters of the R. S., in which the word "gratuitous" was most directly and pointedly introduced) that any misunderstanding could exist, more especially as Sabine said he was sure that Sir H. Pelly had not viewed it in that light, that he and I both thought that it was with a view merely to the regulation of their accounts, and that they might be kept aware themselves, and, if necessary, show to others the expense their liberality in the cause of science had put them to.'

7. CIRCULAR LETTER OF INSTRUCTIONS.

'Lachine, near Montreal, April 26, 1843.

To the Gentlemen in charge of Districts and Posts in the service of The Hon. Hudson's Bay Company.

'GENTLEMEN,—This will be handed to you by J. H. Lefroy, Esq., of the Royal Artillery, who, under the direction of Her Majesty's Government and of the Royal Society, proceeds to the interior for the purpose of making Magnetical Observations; and I have to beg that every facility and assistance he may require, and which the circumstances of the country and service may admit, be afforded him towards the accomplishment of the important and interesting object of his mission.

'Mr. Lefroy takes his passage, accompanied by a servant,[1] by the brigade for the Northern department, to start in the course of a few days hence, and Mr. J. McLean, the gentleman in charge of that brigade, is hereby instructed to afford *two* hours a day for Magnetical Observations; *four* hours at each post, and twenty-four hours commencing from midday on the 26th May and 21st June.

'Should Mr. Lefroy require the assistance of any of the Company's servants for the purpose of conveying him from post to post, or on any other duty connected with his mission, they are to be placed at his disposal, with such craft and appointments as may be necessary; and his demands in clothing and other supplies may be complied with, for which receipts are to be taken from him at each post, and an account opened with the Royal Society, to which will be charged the wages of such servants and the prices of craft, appointments, clothing, &c., &c.

'It is to be understood that Mr. Lefroy is to be at liberty to proceed *to* any part of the country he may desire, and to make such stay at the different posts as he may determine upon; and strongly recommending that gentleman to your kindest personal civilities and attention,

'I remain, &c.

'(Signed) GEO. SIMPSON.'

8. In one particular, at all events, there was no misunderstanding. The kindness of the personal civilities and attentions I received during a stay of eighteen months in the interior did the fullest justice to Sir George Simpson's introduction, and left an impression which lapse of time has not effaced. I was so fortunate as to find at Fort Chipewyan the remains of a library formed by officers of the then extinct North-west Company for their Northern department, comprising many sound books of history and general literature. In the genial society of the late Mr. Colin Campbell, and with the company of a young Canadian clerk, Mr. Dyke Bouchier, I passed a winter there in much comfort, fully employed, and greatly interested in the daily novelties of the fur-trader's mode of life. And here I must say a word on the sterling qualities of my assistant, Corporal William Henry, R.A., then a young soldier, who lived to reach the rank of Colonel on retirement from the army, and who shared the fatigue of daily and nightly observation with a zeal, a cheerfulness, and a strict discharge of duty, which were all that I could wish. Of like quality were the artillery soldiers who accom-

[1] Namely, my assistant, Bombr. W. Henry; I had no other.

panied Sir George Back a few years previously, and of like quality, I doubt not, will be found those who at this moment are assisting Captain Dawson, R.A., in very similar duty at Fort Rae. The ranks of the army can at all times furnish men fit for special services of this nature, and their employment is much to be encouraged, as maintaining the diversified experience, the high standard of intelligence, and the activity of mind, which now enter more than ever into military efficiency.

9. The winter observations having been fully published, it has not been necessary to incorporate them in the present report. They were, I believe, the first which proved the diurnal periodicity of the aurora borealis.

Auroras recorded.[1]

	No.	Brilliancy		No.	Brilliancy
6 P.M.	1	1	1 A.M.	36	48
7 "	8	10·5	2 "	21	18
8 "	14	18·0	3 "	18	26
9 "	17	16·0	4 "	13	22
10 "	19	18·0	5 "	12	15
11 "	23	24·0	6 "	3	2·5
Midn.	32	39·0			

The second column gives the total number of times at which aurora was visible at each hour of the night, and the third gives the sum of numbers assigned on a comparative scale for their estimated brilliancy. Their effect on the magnetic elements is discussed in the work cited below. I have pleasure in inserting the subjoined extract from a letter addressed not long since to Mr. Robert Scott, F.R.S., by one of the observers of the Swedish

[1] See *Magnetical and Meteorological Observations at Lake Athabasca and Fort Simpson, and at Fort Confidence*, 1855, p. 144. Messrs. Lottin and Bravais, in their account of the aurora as observed by the Commission Scientifique du Nord, in Sweden, 1838–40, affirm it only of the successive phases of the phenomenon.

'Cette succession non interrompue' (i.e. the continuity of auroras through successive days) 'n'empêche pas l'aurore boréale de rester soumise aux lois de sa période diurne, du moins relativement à quelques-unes de ses manifestations. Ainsi l'apparition des arcs, des rayons ou des plaques, l'heure où les lueurs se colorent, atteignent leur maximum d'éclat, ondulent ou palpitent, l'heure de leur disparition, etc., ne sont point réglées au hasard ; la période diurne des phases successives est très-évident, et celle des perturbations magnétiques qui les accompagnent ne l'est pas moins' (p. 546.) This very valuable report was not known to me, if indeed it was published in 1843. (There is no date of publication on the title-page.)

expedition to Spitzbergen, which he has kindly communicated to me, to show that the intention, always entertained, that I should devote the winter to observation with the new transportable magnetometers, was justified by the value of the results, which will be more apparent as other stations in high latitudes become available for comparison. The late Sir John Richardson had not the satisfaction of seeing his labours thus utilised, but the appreciation of M. Wykander was acknowledged by his widow in terms of lively gratitude and pleasure.

10. Extract from a Letter addressed by M. Wykander, of the Swedish Spitzbergen Expedition, to Robert Scott, Esq., F.R.S.

'Lund, Dec. 15, 1877.

'It is but some days ago that I got from the University Library the copy of "Magnetical and Meteorological Observations at Lake Athabasca and Fort Simpson, and at Fort Confidence," which you had the kindness to promise me in your letter of the 16th of March. I thank you most sincerely for it; and though the treatise with which I was occupying myself last winter is already printed, that work now allowed me to make a most interesting comparison. I enjoyed reading it so much the more, because the rich materials collected in it confirm fully the conclusions which I had drawn from the Swedish observations, and because many of the opinions pronounced by its authors are in accordance with mine.

'The three places mentioned above have in magnetical respects a situation so resembling that of Spitzbergen—inasmuch as they all have about the same inclination, &c.—as to make it quite natural that the results were to present many analogies. As, therefore, Captain Lefroy has expressly pointed out the importance of the fact that the eastern perturbations of the declination appear in the morning hours, and as he has repeatedly seen the disturbances exhibiting a direction contrary to that of the southern places—for example, to that of Toronto and Philadelphia—it is only the disadvantageous reciprocal situation of the stations that may account for his putting down as definitive the following declaration (p. 88), that "a careful comparison with other published observations has led to the conclusion that a state of magnetical disturbance prevailed at one or more other stations upon so many of the occasions upon which it was observed at Lake Athabasca and Fort Simpson, as to leave it doubtful whether, without more positive evidence, any of the disturbances, considered generally, can be considered to have been merely local."[1] If Toronto and Philadelphia had been situated on a degree of longitude

[1] The writer has long since modified this opinion.

nearer to that of Captain Lefroy's stations, or if Sitka had been more to south, and had not been itself magnetically almost identical to Lake Athabasca, it seems likely to me that his so very careful treatise would have led to a more decisive conclusion concerning the laws for the variations of the disturbances in the arctic and temperate regions. That the same hesitation as to the extensions of the disturbances is to be found with Sir Edward Sabine in his treating the observations at Point Barrow and Port Kennedy, and with those who have treated the observations of Kane and others, may derive from the same reason—viz., the stations in the arctic and temperate regions being situated upon very different degrees of longitude, the currents, or the components of currents, which are passing from the north to the south, or *vice versâ*, and which are producing the disturbances of declination, have not been quite the same at the different stations. The researches that I have made on the observations contained in the work you so kindly sent me, both on the declination and the other components of the magnetic action, have given me the most valuable confirmations of the laws I have pronounced in the treatises which I had the pleasure to send you—viz., that as for the declination and the vertical intensity, there is correspondence between the disturbances of opposite directions at the north and south of the region of the greatest number of auroras; and that, as for the horizontal intensity, the same correspondence takes place between the perturbations of same signs.

'I also fully agree with the declaration of Captain Lefroy (p. 82), "that so regular in their operations in these regions are the so-called irregular influences, that the denominations might with propriety be reversed." It seems necessary to assume that, as has been proved by several authors, there be two, as one may say, regular sources of the magnetic variations: one proceeding more directly from the heat of the sun and culminating towards the tropics, the other proceeding—not, as has been supposed, from the magnetic pole—but from the region of auroras, or from a zone almost coinciding with that region.

'It was most interesting to find that the three abovesaid stations are all lying at the north of that zone. Consequently, this zone is situated much more south in North America than in Europe, where it passes just at the north of Norway, and also for this reason is very likely to be really identical with the region of auroras. Sitka also seems to be situated at the north of this zone, or at least to be lying in it. I regret ignoring where the Sitka observations are to be found, or even whether there be any complete series of them published.[1]

'It would lead me too far to make a detailed comparison between our observations and those of Captain Lefroy and Sir J. Richardson. The analogy is most remarkable, also, in the regular variation of all the components; yet, as for the afternoon minimum of the declination, the

[1] They were incorporated by M. Kuppfer in the *Annuaires*, 1841–45.

northern position of Spitzbergen, and the consequently diminished intensity of the heat of the sun, make their influence sensible.

'Believe me, &c.

'AUG. WYKANDER.'

11. The direction of the Earth currents at Lake Athabasca was investigated by Dr. Lloyd in 1862 ('Proceedings' Royal Irish Academy), with the result that an easterly current prevails there from midnight to 6 A.M. having an azimuth of 110°, and a westerly current during the remainder of the 24^h having an azimuth of 291°. The easterly currents were greater in magnitude in proportion as they were less in duration; at Toronto the current is wholly easterly, the mean azimuth found by Lloyd being 81° 25′, while at Sitka the westerly currents are greater than the easterly, the geographical position of the station in reference to the distribution of land and sea being proved to have an unexpected influence on this source of magnetic movement.

12. The preparation of this volume has required me, after an interval of many years, to retrace the steps of Sir Edward Sabine, the pioneer of the modern science of terrestrial magnetism in this country. I must allow myself to express the admiration that has been revived for the general accuracy of detail, and the astonishing industry that marks his 'Contributions to Terrestrial Magnetism.' In his comprehensive view of the subject, however, features of merely local interest were apt to disappear; this is especially the case with local disturbance, or irregularity due to geological causes; he only noted four stations of mine as thus affected, namely, the Isle d'Urval (No. II), Otter Island, on Lake Superior (No. LVIII), a Station on Rainy River (No. XCI), and Pierre au Calumet, on Mackenzie's River (No. CCXXVI); several others were disposed of by being simply omitted. This, however, is doing less than justice to a very interesting feature presented in all extensive magnetic surveys, and one which, when the subject of earth currents comes to be better understood, will probably prove to possess considerable importance. I have, therefore, rejected no observation because of its anomaly, where there is no internal appearance of error, and by bringing together all the elements, and all the evidence, derived

in the case of the force, from data independent of one another, have in many cases shown the existence of local anomaly, probably due to geological causes, and established a fact which, if it has no other value, will at least influence the selection of stations by future observers.

The lines of equal inclination and equal intensity are laid down on the maps accompanying this volume in near accordance with the actual observations, each station of observed dip giving two points. It is not to be supposed that a local influence necessarily covers all the distance to the next isoclinals; but without multiplying stations its limits are unknown. For example, a considerable inflection of the line of 81° will be observed near Lake à la Crosse resulting from the anomalous dip at the Portage Sonnante (CCX); the values at the Fort on the same lake, and at Fort Pitt further south, showing that it does not extend to the lines of 80° and 79°. It would appear that the greater inflections of the isoclinals bear some relation to the courses of the rivers; but whether this is due to any influences of the rivers themselves upon electric currents, or is an incidental result of the watercourses, in so many cases in Northern America, marking the line of junction of two dissimilar geological formations, I am not competent to decide. The direction of the isoclinals of 83° and 84° towards Hudson's Bay; of 82° and 83° in the valley of Mackenzie's River; of 77° and 78° towards the Gulf of St. Lawrence, are good examples of the effect in question. There are also several examples of less extensive inflections, as, for instance, to the south of Lake Athabasca, on either side of Lake Winnipeg, and on the Lake of the Woods. Dr. Lamont's admirable magnetic chart of Bavaria[1] shows deflections apparently connected with the beds of the Rhine, the Maine, and the Danube. The like has been proved of the Coal Fields of Belgium by the Rev. S. J. Perry.[2]

I have pointed out on pp. 35 and 151 that the position of the line of relative total force 1·80, or 13·62 in absolute measure, as laid down on the map, engraved in 1846 for the late Sir E. Sabine's

[1] Lamont's *Magnetische Karten von Deutschland und Bayern.* München, 1854.
[2] *Phil. Trans.* 1873.

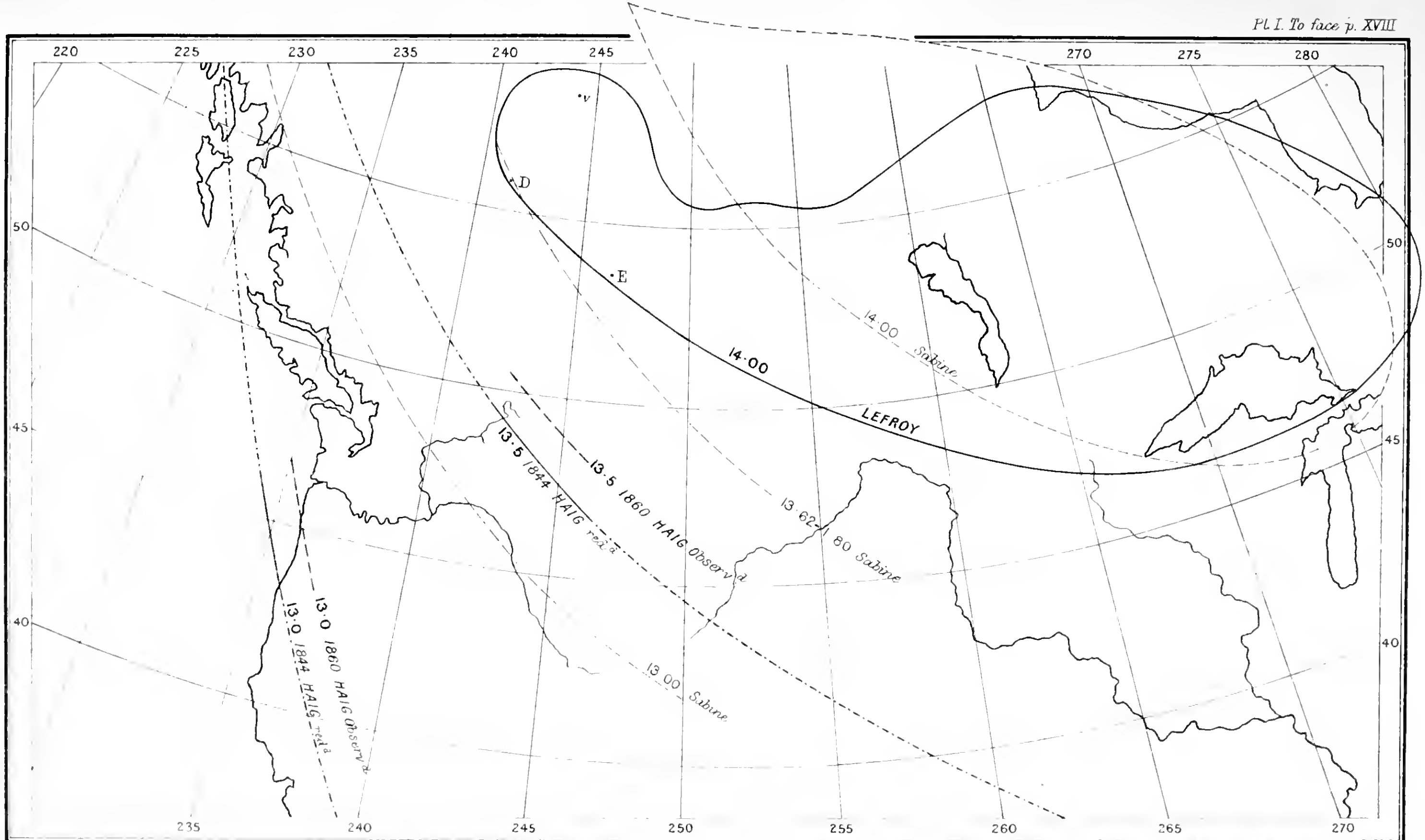
contribution No. VII, does not accord with my observations on the Saskatchewan. I had not observed when those paragraphs were printed that the map entitled 'An Arctic Magnetic Survey, Epoch 1840-1845,' which accompanies his contribution No. XIII of 1872, is in this particular a reproduction of the earlier one. The isodynamic lines laid down are those of 13·0 and 14·0; but, on interpolating a line for 13·62, it will be found to fall where the line of 1·80 was formerly drawn. Now the maps herewith profess to give the facts of observation on the American continent, and not what may be, possibly, the best mean results of a general survey of the Northern hemisphere; and it is perhaps incumbent on me to show that my results are *locally* correct, which is the special business of the observer, by other and independent evidence. Fortunately Captain R. W. Haig, R.A., laid down the lines of 13·0 and 13·5 in British Columbia from his own observations in 1858–1860.[1] They are shown on the annexed diagram, lying far to the west of General Sabine's position, and the effect of applying a correction for the secular change of the force in 16 years is to move them yet further in the same direction. The 'Report of the United States Coast Survey' for 1881 having appeared at the last moment for the correction of this work, I take from the appendix by Mr. Charles A. Schott,[2] the data it furnishes for estimating the secular changes since 1840 over the region I treat of. The general evidence is conclusive that in middle latitudes on the American continent the intensity of the earth's magnetic force is now decreasing, and has been decreasing for about 35 years. It was therefore greater in British Columbia in 1844 than Captain Haig found it in 1860, and I have felt justified in moving his lines of 13·0 and 13·5 to the west, by about the space equivalent to 0·10 of total force. The agreement of his results with mine when thus reduced to the same epoch is complete.

[1] *Phil. Trans.* 1864.

[2] Appendix No. 9, by Charles A. Schott.—Terrestrial Magnetism; Collection of Results for Declination; Dip and Intensity, from observations made by the United States Coast and Geodetic Survey between 1833 and July 1882. Washington, 1883.

DIAGRAM SHOWING THE DIFFERENCE BETWEEN THE ISODYNAMIC LINES IN NORTH WEST AMERICA AS LAID DOWN FROM THE OBSERVATIONS, AND AS THEY WERE DRAWN ON THE CHART OF 'ARCTIC MAGNETIC SURVEY'. EPOCH 1840-5. PHIL. TRANS. 1872.

Pl. I. To face p. XVIII



List of Stations in N. America affording Data for determining Secular Change. The earlier Observations, when not given by Mr. Schott, will be found in Sir E. Sabine's Collections.

I.—*On the Atlantic Coast.*

Place.	Lat. Long.[1]	Date	Var.	Dip	Force	Observer
	° ′		° ′	° ′		
St. Pierre,	46 46·9	1872·5	29 25·5	74 37·9	12·05	Goodfellow
Miquelon	56 10·6	1881·8	28 20·8	75 2·0	12·60	Very
Quebec,	46 48·4	1842·8	14 12·0	77 15·3	13·84	Lefroy
Canada	71 14·5	1845·5	—	77 8·8	13·63	Younghusband
		1859·5	16 17	77 17·5	13·60	Schott
		1879·7	17 13·7	76 45·1	13·54	Baylor
Montreal,	45 30·5	1842·7	8 58	77 13·1	13·72	Lefroy [a]
Canada	73 34·9	1843·3	—	77 8·8	13·76	,,
		1845·5	—	77 8·5	13·53	Younghusband [b]
		1859·5	12 21	76 51·4	13·68	Schott
		1879·7	13 40·5	76 25·7	13·60	Baylor
Halifax,	46 39·5	1838·5	—	74 45	—	Estcourt
Nova Scotia	63 35	1847·5	—	75 37	13·07	Keily
		1879·7	20 43·3	74 39·2	13·04	Very
		1881	—	74 29	12·93	
Bangor,	44 48	1841	—	76 11·6	—	Graham
Maine	68 47	1857·7	15 19·9	76 14·7	13·59	Dean
		1863	—	76 5·3	13·34	Schott
		1879·6	—	75 29·8	13·24	Baylor
Portland,	43 38·8	1851·6	11 41·1	75 14·1	13·54	Hilgard
Maine	70 16·6	1859·5	12 20	74 56·7	13·31	Schott
		1864·8	12 43·7	75 9·5	13·49	Richardson
		1865·5	12 42·3	75 8·3	13·49	,,
		1866·2	12 42·9	75 7·4	13·47	,,
Cambridge,	42 22·8	1842·8	—	74 19·5	13·46	Lefroy
Mass.	71 7·6	1870·6	11 46·3	73 48·4	13·29	Baylor
Dorchester,	42 20	1842·8	—	74 12·8	13·33	Lefroy
Mass.	71 2·6	1846·7	9 31·4	74 12·7	13·18	Lee
		1855·6	10 13·7	74 29·5	13·26	Schott
Providence,	41 49·5	1842·8	—	74 0·0	13·48	Lefroy
Rhode Isl	71 23·9	1855·6	9 31·5	74 15·9	13·24	Schott
Newhaven,	41 18·0	1842·8	—	73 27·4	13·45	Lefroy
Conn.	72 55·4	1844·6	5 45·1	73 24·2	13·51	Renwick
		1845·7	6 17·3	—	—	,,
		1848·6	6 37·9	73 31·9	13·32	Ruth
		1855·6	7 2·7	73 44·5	13·18	Schott

[1] The Latitudes and Longitudes are Mr. Schott's, and correct some of those at pp 53 and 166.

I.—*On the Atlantic Coast* (continued).

Place	Lat. Long.	Date	Var.	Dip	Force	Observer
	° ′		° ′	° ′		
Sandy Hook,	. 40 27·7	1844·6	5 51	72 37·9	13·66	Renwick
New Jersey	. 74 0·2	1855·6	6 11·2	72 52·0	13·30	Schott
		1873·9	7 9·0	72 29·6	13·43	Hilgard
		1879·5	7 32·0	72 8·3	13·30	Baylor
Philadelphia,	. 39 58·4	1842·8	—	71 59·0	13·58	Lefroy
Girard Coll.,	. 75 10·2	1846·4	3 51·1	72 1·0	13·42	Locke
Ohio		1855·7	4 31·7	72 17·7	13·90 ?	Schott
		1862·6	5 0·0	72 5·8	13·42	"
		1872·8	5 27·8	72 15·4	13·65	"
		1877·8	6 2·2	71 41·3	13·40	Baylor
Washington .	. 38 53·1	1842·8	—	71 13·8	13·41	Lefroy
I. *Capitol* .	. 77 0·6	1852	—	71 16·1	13·29	Hilgard
II. *Corner, Second,*	38 53·1	1867·5	2 48·1	71 6·7	13·347	Schott
and C Streets	77 0·2	1872·5	3 0·0	71 0·6	13·399	"
III. *Corner, First,*	38 53·2	1877·5	3 39·4	70 49·1	13·292	"
and B Streets	77 0·4	1882·5	3 55·4	70 44·1	13·227	Eimbeck
IV. *Old Coast*	38 53·1	1845·2	—	71 33·8	13·40	Lee
Survey Office	77 0·6	1856·6	2 21·4	71 21·7	13·48	Schott
		1858·5	—	71 22·6	—	"
		1859·5	—	71 24·4	—	"
		1860·7	2 26·7	71 15·9	13·446	"
		1861	—	71 18·3	—	Walker
		1862·6	2 39·4	71 18·5	13·368	Schott
		1863·5	2 41·8	71 14·3	13·351	"
		1865	—	71 11·7	—	"

II.—*Inland Stations.*

Place.	Lat. Long.	Date	Var.	Dip	Force	Observer
	° ′		° ′	° ′		
Burlington,	. 44 29·3	1855·6	9 57·1	75 56·8	14·10	Schott
Vermont	. 73 13·4	1873·0	11 19·0	75 24·2	13·60	Hilgard
Albany,	. 42 39·8	1839	—	74 51·3	—	Loomis
New York	. 73 45·1	1841	—	74 40·1	—	Bache
		1841	—	74 39·9	—	Nicollet
		1842	—	74 44·6	13·60	Lefroy
		1844	—	74 40·2	—	Locke
		1858·4	8 17·0	74 55·6	13·79	Dean
		1879·8	9 51·7	74 18·9	13·48	Baylor
Toronto,	. 43 39	1843	1 24	75 14·7	—	Observatory
Canada	. 79 21	1845	1 29·1	75 15·5	13·942	"
		1849	1 36·9	75 18·8	13·952	"
		1859	2 7·2	75 25·0	13·825	"
		1871	2 48	75 16·8	13·776	"
Cleveland,	41 30·5	1842·9	—	73 3·8	13·67	Younghusband
Ohio .	81 41·5	1871·9	0 32·6	73 9·3	13·80	Goodfellow
		1880·5	1 38·5	73 2·4	13·70	Baylor

II.—*Inland Stations* (continued).

Place Lat. Long.		Date	Var.	Dip	Force	Observer
	° ′		° ′	° ′		
Columbus, *Ohio*	. 39 57·7 . 82 59·7	1838	—	71 4·9	13·53	Locke
		1841	—	71 3·7	—	Loomis
		1845	—	71 4·3	—	Locke
		1871·8	− 1 20·6	71 9·8	13·53	Mosman
Sault S. Marie, *Mich.*	46 29·9 84 20·1	1844·9	− 1 1·1	—	13·82	Lefroy
		1845·5	—	77 19·5	—	Rae
		1880·6	+ 0 53·7	—	—	Very
		1880·6	+ 1 4·5	77 24·0	14·01	Baylor
Mackinac, *Mich.*	. 45 51 . 84 40	1842	—	76 37·0	14·10	Locke
		1880·5	0 20·5	76 27·6	13·94	Baylor
Cincinnati, *Ohio*	. 39 8·6 . 84 25·4	1841	—	70 26·5	13·59	Locke
		1849·4	—	70 28·8	13·55	Lefroy
		1880·9	− 2 14·4	70 24·7	13·39	Baylor
Vincennes, *Indiana*	. 38 41·7 . 87 31·6	1840	—	69 51	13·56	Locke
		1841	—	69 52·8	—	Loomis
		1880·8	− 4 22·5	69 53·4	13·44	Baylor
New Harmony, *Indiana*	38 8 87 50	1840	—	69 3·6	13·46	Locke
		1848·9	− 6 47·0	69 7·2	13·59	Fauntleroy
		1861·3	− 6 43·5	—	—	—
		1880·9	− 5 5·1	69 2·6	13·31	Baylor
Madison, *Wisconsin*	. 43 4·5 . 89 24·2	1839	—	—	14·09	Locke
		1876·8	− 6 59·7	73 54·8	14·04	Hilgard
		1877·7	− 6 44·9	73 55·5	14·13	Braid
		1878·7	− 6 31·8	73 56·5	14·07	Suess
		1878·9	− 6 22·9	73 55·1	14·06	Baylor
		1879·7	− 6 21·9	73 51·0	14·03	Mason
		1880·7	− 6 20·9	73 49·5	14·00	”
Dubuque, *Iowa*	. 42 29·5 . 90 44·0	1839	—	73 5·0	13·76	Locke
		1880·8	− 6 45·8	73 7·8	13·69	Baylor
Davenport, *Iowa*	. 41 29·9 . 90 38·0	1839	—	71 55·1	13·76	Locke
		1877·8	− 7 2·8	71 56·6	13·79	Braid

III.—*On the Pacific Coast.*

Place. Lat. Long.		Date	Var.	Dip	Force	Observer
	° ′		° ′	° ′		
Sitka, *Alaska*	. 59 2·9 . 135 20·3	1827·5	−28 50	75 55	12·98	Lütke
		1830	−28 16	75 51	12·90	Erman
		1838·5	−28 37	75 51	12·77	Belcher
		1842·5	−28 53	75 51	—	Observatory
		1851	−29 14	76 20	—	Collinson
		1880·4	−29 4·8	75 11·7	12·95	Dall
		1881·7	−29 11·2	75 16·6	12·91	Nichols
Esquimault, *B. Colum.*	. 48 25·4 . 123 26·3	1859	−21 58	71 34	13·10	Haig
		1881·7	−22 55·6	71 30·3	12·87	Nichols

We have here twenty-one stations widely distributed, which show a marked decrease of intensity, and only one, St. Pierre Miquelon, where the change is the other way. At seven stations the evidence is inconclusive, from the long intervals without observation. In all probability the force increased in the earlier part of these intervals, and has been decreasing since. It is not my object, however, to discuss the secular changes, but to establish my conclusion that the lines of equal total intensity in British Columbia in 1844 were, as I have drawn them, to the westward of their position in 1860.

The return of Captain H. P. Dawson from Fort Rae, Great Slave Lake, where he has passed twelve months in observations connected with the International Circumpolar expeditions, enables me also to add, with his permission, and that of the Council of the Royal Society, that he found the dip at Fort Chipewyan (CCXXIX) on September 17, 1883, 81° 20′·6.

If we may assume that this element attained its maximum value at Lake Athabasca at the same epoch as it did at Toronto (1859), it was probably again the same in 1874 as it was in 1844, and we have therefore for the present rate of secular change of dip in that quarter—1′·7 per annum.

Attention should have been more pointedly drawn in the text (pp. 96–99) to the remarkable development of magnetic force on the Eastern side of Lake Winnipeg, between lats. 51° and 52½°, longs. 96°–97° W. It is so great as to make it doubtful whether the physical pole of maximum intensity should not be located here, 4° to the west of its theoretical position; but the remark on p. 48, that there is a secondary focus in or about lat. 56°, long. 106°, must be qualified. The increase in that neighbourhood appears to be but a local disturbance.

I had the serious misfortune to lose in 1846 a part of my baggage in which were contained three MS. volumes of Journal. Thus a great quantity of descriptive notes and details which would have been of service for the present publication were irretrievably lost, and the trouble I have had in recovering many particulars from other sources has been, to myself at least, an ample proof of the necessity for it.

December, 1883. J. H. LEFROY.

CONTENTS.

Errata and Corrigenda.

Page 9, line 6, *for* date *read* data.
,, 11. The Table should be numbered II.
,, 15. ,, ,, ,, III.
,, 19, line 17, *delete* 'two.'
,, 48, ,, 23, *delete* B. 56, 106.
,, 49, Secular changes, see the Preface.
,, 52, The Dip at Stanstead is 76°19′·2 *not* 77°19′·2.
,, 72, ,, 7. *Delete* This is the greatest force (*see* CXXI. p. 97). Lieut. Very, U.S.N., found the variation at Michipicoton 1°20′·5 W., X 2·860 in July 1880.
,, 79, ,, 10. The weight (0·75) belongs to this line.
,, 80, ,, 16. Insert *W.* (0·85).
,, 81, ,, 20, *for* 5·48 *read* 5 4·8.
,, 83. The *Portage des Morts* is the same as the *Pine Portage* of some maps.
,, 84, *for* 91.23 *read* 91.28 foot of page.
,, 84. Franklin, whose nomenclature was followed by the author, has *Upper Sturgeon Lake*, between Lac de Mille Isles and Lake à la Crosse, and *Sturgeon Lake* beyond Lake à la Crosse.
His Sturgeon Lake is miscalled Lake à la Crosse on Prof. H. Y. Hind's map, and is now called Nameucan Lake.
Franklin's Lake à la Crosse is called Pine Lake on Prof. Hind's map, and is now called Nequaqua Lake on maps published by authority.
,, 85, lines 14–15 from bottom, *for* W. (1) (2) *read* W. (2·5)—(6·0).
,, 88, line 16, *for* 94·3 *read* 94·37.
,, 89. I learn from Professor Dawson that a remarkable geological fault occurs at Rat Portage, and accounts for much disturbance.
,, 92, lines 5–4–3 from bottom, *for W.* (1·5) *read W.* (1·0).
,, 93, line 12, *after* 14·128 *write* W. (0·6).
,, 95, ,, 15, *for* 14·056 *read* 14·050; line 31, *for* 51° 36′ *read* 51° 3′·6.
,, 99, ,, 6, *after* 14·396 *insert W.* (0·3).
,, 100, ,, 14, *for* 14·113 *read* 14·125.
,, 101, ,, 7, *after* 14·162 *insert* W. (0·9).
,, 107, ,, 16, *after* 14·191 *insert W.* (1·2).
,, 116 ,, 7, *for* 58°3′·50 *read* 58°43′·8; line 8, *for* 86°47′·3 *read* 86°18′·3; line 9, *insert* July 18, *delete* 2.
,, 121, last line, *for* 1·8624 or 14·096, *read* 1·8716 or 14·165.
,, 127, ,, *for* 14·054 *read* 14·116.
,, 128, line 5, *for* 14·061 *read* 14·109.
,, 149, ,, 23, *for* Pembine *read* Pembina.
,, 166. Station 21, p. 53, has been accidentally omitted; Station 5, Stanstead, Dip *for* 77°19′·2 *read* 76°19′·2.

A MAGNETIC SURVEY.

PART I.

INSTRUMENTS AND MODES OF OBSERVATION.

1. The instrumental equipment provided for the magnetic survey now to be described was composed as follows :—

(1) A Dip Circle by George, of Falmouth, of the construction of the late Mr. Robert Weare Fox. It weighed in box complete, with stand, 37 lbs.

(2) A nine-inch Dip Circle by Gambey, with stand, 27 lbs.

(3) A six-inch Transit Theodolite by Jones, with stand, $10\frac{1}{2}$ lbs.

(4) A Declination Magnetometer, with stand, 25 lbs.

(5) A Transportable Declinometer of Weber's construction, subsequently replaced by the much superior instrument made by Jones under the directions of Lieut., now Major-General, C. J. B. Riddell, R.A.

(6) A Transportable Bifilar, to which the same remark applies. The two weighed, with necessary stands, 22 lbs.

(7) A Lloyd's Induction Inclinometer, made by Jones, for one bar, with stand, 18 lbs.

(8) An Azimuth Compass of the Admiralty Committee's construction, by Barrow, with stand, $5\frac{1}{2}$ lbs. I received this instrument through Sir George Simpson in Montreal on the eve of my departure.

(9) A Repeating-Reflecting Circle by Dollond, with Mercurial Horizon, 25 lbs.

(10) A small Portable Transit Instrument, the telescopic power of which proved too small for observing small stars in strong moonlight, but it was very useful for rating the chronometer when stationary in the winter.

(11) Two Portable Barometers, each $4\frac{1}{4}$ lbs.—$8\frac{1}{2}$ lbs.

(12) Two Pocket Chronometers, $\frac{1}{2}$ lb.

To the foregoing, which amount in weight to about 180 lbs., must be added a Pocket Compass, some Thermometers, 'Nautical Almanacks' for 1843 and 1844, Raper's 'Navigation,' blank books and forms, stationery, and numerous minor requisites.

My personal equipment comprised a small tent, with bedding, a *cassette* or clothes chest (100 lbs.), a canteen (64 lbs.), a provision basket (40 lbs.), a gun and rifle, my assistant's valise, about a fortnight's provisions for the crew, and their slender effects, all of which, with the canoe itself, which weighed 4 cwt., had to be carried over the Portages, a work in which Corporal Henry and myself invariably took a share when not employed on observation.

2. The instruments suffered severely in their journey by stage from Toronto to Montreal in April; there was then no railway, and navigation was not open. The two dip circles were almost shaken to pieces. Lloyd's static needles lost force from the effect of the jolting to such a degree as to entirely disconnect the subsequent observations from those intended to be the base series, taken at Toronto. The same remark applies to Fox's needle C, and a new base had to be taken for both, at Fort William (Station LXIX). The instruments were reinstated, as well as could be done, before starting.

3. A few words are necessary with respect to the observations made. I begin with those for assigning geographical position.

In observations made at sea, which are usually taken at points on the earth's surface a hundred miles, more or less, apart (being seldom made more than once in twenty-four hours), and when the ship itself may change its position several miles during the progress of a long observation; where, moreover, the future identification of the locality is impossible, it matters little whether the geographical co-ordinates assigned are rigorously accurate or not. The observer marks them as he marks the ship's track on his chart. It is otherwise on land, where the recovery of the identical spot on which former observations were made is not excluded by any impossibility, and is always of some consequence. Nevertheless there are often no definite or recognisable landmarks, and, in unsurveyed countries, often no name for the locality. Hence it becomes of importance that the geographical co-ordinates assigned for the place of each observation, particularly when the places are not far apart, should be sufficiently accurate to be sensibly correct when plotted on a map. Casting a retrospect over my own preparation and previous instruction, it now appears to me that both the importance and the difficulty of this degree of precision were somewhat overlooked, and I cannot hope to have always attained it. Sometimes for days together there were no sights to be had. I trusted much Franklin's track-routes; but his positions are not always consistent, and the best maps of later date, most of the country being still unsurveyed in any strict sense, often differ from him. In the present revision I have availed myself of all sources of information to correct my longitudes, and to place the localities of observation as correctly among themselves as present geographical knowledge permits. The territory of the Hudson's Bay Company has witnessed surprising changes since 1843. New routes have been opened and old ones abandoned; for example, the circuitous canoe route above Fort William by Dog Lake and the Long Portages to the Lake of the Thousand Islands, is quite deserted, and probably no longer practicable. The old race of *voyageurs* from Lower Canada is dying out, if not already extinct, and with them will in time disappear the traditionary and often historical names of places, especially of the Portages, to be replaced in a generation or two by vulgar Anglo-American names.[1] Travelling with French-speaking guides and voyageurs, I naturally called places by the names they gave them, and by these they were formerly published. I now add current English designations as far as known. I learnt at Montreal in 1877 that one of my Indian guides was still living, and what is more remarkable, that Jean-Baptiste Belanger, a partaker of the sufferings of Franklin, Richardson, and Back in 1821, was also living. But time will rapidly efface the traces of the fur trade over most of the country, as it has already done in the Rocky Mountain States.

4. *Latitude.*

The instrument employed was an eight-inch repeating-reflecting circle, by Dollond (now at Kew). It was my practice, with the sun, invariably to observe altitudes first on, then off the limb, so as to eliminate index error. Stars were generally observed on the limb

[1] Thus, Qu'appelle, on the river of that name, having been degraded to 'Q. Apple,' has been recently rechristened Regina.

only, and the index error was frequently ascertained; it was never more than 37″ or less than 17″. The horizon glass was reversed between each pair of sights; the glasses of the roof being of indifferent quality, reversal made a difference of about 56″. I rarely used the instrument as a repeating circle except for lunar distances.

The latitude was observed every day at noon when the sun was visible, and when it was possible to put ashore for the purpose, and was worked back or carried forward by courses and estimated distances to the station of A.M. or P.M. observation. Towards the end of the season, when the stars appeared early, it was usually ascertained also by altitudes of Polaris at night. The method of reduction by circum-meridional altitudes has been always employed, as it not unfrequently happened that the meridian was passed before the first sight. The barometric correction is always small, and after the breakage of my barometer on June 18 was necessarily omitted. In the present revision I have applied mean corrections based on the height of the region above the sea.

In Table IX., 'Phil. Trans.' 1846, latitudes were given to the nearest decimal of a minute; but as astronomical observations of a high order have recently been extended by the Surveyors of the Dominion of Canada as far as the Saskatchewan, I now give them for comparison to the last second, without, however, supposing that it is possible for a traveller to make sure of his results by sextant observations to that degree of precision, still less to the decimal parts of a second, with which books are often incumbered. Franklin's latitude of Cumberland House (Station CLXXXIII) in 1825 is 53″ greater than in 1819, and of Fort Chipewyan (CCXXIX) 5″ less, being the only stations common to both journeys. I did not observe it at Cumberland House, and differ from him 28″ at Fort Chipewyan.

5. *Longitude.*

I started with two pocket chronometers, lent by Captain, afterwards Sir Francis, Beaufort, R.N., Hydrographer—Arnold No. 138, and Barraud No. $\frac{2}{503}$. The stationary rates furnished with them were $-3^s{\cdot}7$ and $-2^s{\cdot}0$ respectively; but these altered much in travelling, and, to judge by their numbers, they were very old watches. I also carried a new half-chronometer of my own, No. 5,242, which proved a most worthless timekeeper, notwithstanding the name of repute it bore.[1] No. $\frac{2}{503}$ was carried by my assistant, Corporal Henry, and met with some accident on July 12, which caused it to stop; on examination in London one of the jewels proved to be fractured. In September 1844 I received at Norway House another chronometer, No. 2,142, in its place. These watches were wound up and compared daily at the halt for breakfast. It would have been better, looking to the irregularity of their travelling rates, to have compared them twice in the twenty-four hours. Their error, on Greenwich mean time, was carefully determined at each station of well-ascertained longitude, and thence their mean rates for short intervals deduced, for placing the intermediate stations. I have long looked for the extension of the electric telegraph to the North-West for better data, but, although it had reached Edmonton in 1876 (113° W.), no such use has yet been made of it. Mr. W. H. King has, however, ascertained astronomically the longitude of three important points on my route,[2] which I have used for the correction of others.

My practice was to observe the sun's altitude every morning, weather permitting, at the breakfast halt, and often also in the afternoon, reducing the results with a latitude found at noon and reduced to the station. With the exception of twenty-one stations, between July 1 and August 25, 1844 (about one thousand two-hundred miles in distance), I travelled over very little ground not laid down on the route maps of Franklin's celebrated expeditions of 1819 and 1825. These maps, however, were engraved for the narrative of the first expedition, and not corrected by the second. Bayfield's surveys, recently republished with longitudes corrected, were of the greatest service on the great lakes. Route maps by Messrs. Dawson and Napier from Lake Superior to Red River (Ordnance Survey Department, 1870), of the Lower Saskatchewan by Professor H. Y. Hind (1859), of Lake Winnipeg, Nelson River, and York Rivers by Dr. Robert Bell, of the Geological Survey (1878), have all been of great assistance to me in recovering details after so long an interval of time.

I subjoin for the convenience of future travellers a list of the meridians which may be regarded as well determined down to this time, not including the standard meridians of the Territorial Survey now in progress.

[1] The steel parts of this watch had very possibly become magnetised: the same cause may have contributed to the irregularity of the chronometers.

[2] Annual Report of the Department of the Interior, Ottawa, 1880.

TABLE I.

Station	Longitude, W.		Authority F. = Franklin
	Arc	Time	
	° ′ ″	h m s	
Citadel, Quebec	71 12 0	4 44 49·	
Montreal (Viger Sq.)	73 32 55	4 54 11·7	Captain Ashe, R.N.
Sault St. Mary	84 21 33	5 37 26·2	Michigan State Survey.
Fort William	89 13 30	5 56 54·	From revised chart.
Fort Francis	93 24 36	6 13 38·4	A mean value.
Rat Portage	95 33 19	6 22 13·3	Boundary Commission 1826.
Fort Alexander	96 22 20	6 25 29·3	A mean value.
Fort Garry, Winnipeg	97 15 36	6 29 2·4	Boundary Comm., 1872.
Norway House	98 3 54	6 32 15·6	A mean value.
York Factory	92 26 0	6 9 44·	F., first voyage.
Grand Rapid, W.	99 27 44 99 28 3	6 37 51·6	F., first voyage. F., second voyage.
Cumberland House	102 19 13	6 49 16·9	F., first and second voyages.
Carlton House	106 32 1	7 6 12·	Dominion Survey.
Edmonton House	113 30 19	7 24 1·3	"
Lesser Slave Lake	116 0 0	7 44 0·	Six sets of lunar distances, L.
Isle à la Crosse	107 52 55 107 54 36	6 31 35·3	F., first and second voyages.
Methy Portage, S.E.	109 52 54	7 19 31·6	F., second voyage.
" " centre	109 57 54	7 19 51·6	"
" " N.W.	109 59 8	7 19 56·5	"
Fort Chipewyan	111 18 20 111 19 19	7 25 14·7	F., first and second voyages.
Fort Resolution	113 45 0	7 35 0·	F., second voyage.
Fort Simpson	121 33 0	8 6 12·	F.'s map corrected.
—	121 25 15	8 5 41·	T. Simpson, 1837.

6. A traveller who relies on chronometers should not carry a less number than three. Given, however, the daily difference between two chronometers whose *mean* rate is known, we can obtain some clue to their irregularities, for if their going be uniform, the difference between them must increase or diminish daily by the sum of their mean rates. Applying this principle to the daily comparison of Nos. 138 and $\frac{2}{503}$ between May 29 and June 30, it was obvious that the rate of one or both was very much larger than the mean for the first ten days, and less than the mean for the next twenty. The former period included all the long Portages which occur about the height of land. It also appeared that the application of the mean rate to No. 138 gave longitudes in fair accordance with Franklin's, the greatest deviation being 18′ and the average deviation 7′ for stations which can be compared; whereas the application of the same rule to No. $\frac{2}{503}$ gives results as much as 30′ too far to the west, whence it may be fairly assumed

that No. $\frac{2}{503}$ was the one most affected under the circumstances. Having obtained this clue, I distributed the irregular excess in the arbitrary proportion of *one-third* to No. 138 and *two-thirds* to No. $\frac{2}{503}$, with the result that the two Greenwich times thus obtained do not on the average of twenty-two stations differ more than $17^{s}\cdot6$, and the extreme difference is under 40^{s} or $10'\cdot0$ of arc.

7. *Magnetic variation.*

The variations are comprised between 28° W. and 45° E. (the former was observed towards the mouth of the River St. Lawrence). They were principally determined by observations of the sun's azimuth with a seven-inch compass, of what was then known as the Admiralty Committee's construction, but partly by the employment of a collimator magnet. The chief novelty in the compass was the employment of the directive force of several parallel magnets under the card, instead of one only. They had the desired effect of making the magnetism more powerful; but, on the other hand, they made the card much heavier and its freedom of motion more easily checked by the least dirt or a slight imperfection either of the pivot or of the jewel on which the card worked. The compass was furnished with several pivots. It should have had also a spare jewel made to screw into the card, but this was not thought of. The collimator magnet was tubular, with a scale at one end, seen by reflected light through a lens at the other end, suspended in an oak box by a silk fibre about nine inches long. The axis of a theodolite was brought into coincidence with the axis of the magnet, which coincided with Division 81·5, or as nearly so as its movements permitted; after reading off the limb, it was directed upon the sun, whose hour angle being known, its azimuth was computed in the usual way. The torsion of the silk suspension was approximately got rid of by first suspending a brass bar; and the magnetic axis was ascertained by occasional reversals of the magnet in its hook supports. This method is in principle far more precise than observation by compass, where there is greater liability to index error,[1] and less freedom of motion; but the oscillations of the magnet in the open air, particularly if there is a little wind, make it less easy to get a true coincidence of the axis of a detached theodolite with that of the magnet than might appear, and I must

[1] I have lately found a high-priced portable azimuth compass 2° in error.

acknowledge that the results of variation are less harmonious than I could wish. The element itself fluctuates much more than any other, and although we know with some certainty what its ordinary limits are in high latitudes in the winter months,[1] we do not yet know what they are in the summer months. It is also much more affected than any other by the character of the superficial strata, and the position of different formations relatively to the magnetic meridian at any given spot. Thus in one place on Lake Superior, Captain Bayfield marked on his chart of 1828 variation 3° 50′ *West*, and the two adjacent values within a few miles on either side are 6° *East*, 7° *East*. This influence is the greater, the less the directive force, or the greater the dip. I am not acquainted with any very extensive series of observations of variation on land taken from day to day at short intervals of distance; Sir John Franklin, however, has six observations within the same limits (not counting those at which the only datum is the sun's bearing at noon), and these present anomalies of the same nature. For example, June 5, 1825, at Fort Alexander (Station LXXXII); variation 15° 15′·6 E., on the same day at a station not five miles distant, variation 13° 17′ E. The magnetic survey of the British Islands 1856–7 furnishes several examples of declination deviating a degree or more from the normal values,[2] as does the Australian survey of Dr. George Neumeyer in 1858–64. The greatest distance between the stations of this observer being only thirty miles, and many of them being only eighteen or twenty miles apart, they assimilate very much to the conditions of my own. I quote as an extreme instance his station at Moonmot (No. 73) in Victoria, 1860, lat. 37° 38′·5, long. 143° 23′ E. He found variations respectively 5° 54′ E., 15° 53′ E., and 7° 2′ E. within a very small circle, the force ranging at the same time from 4·67 to 5·11. Dr. Neumeyer attributes these irregularities to the great local attraction caused by the volcanic rocks forming this point of irruption,[3] and the same conditions occur at many points in the present survey, notably about Lake Superior.

[1] See *Magnetical and Meteorological Observations at Lake Athabasca and Fort Simpson*, by Capt. J. H. Lefroy, R.A., and at *Fort Confidence, in Great Bear Lake*, by Sir John Richardson, C.B., M.D., 1855.

[2] *Phil. Trans.*, 1870.

[3] *Results of the Magnetic Survey of the Colony of Victoria, executed during the Years* 1858–1864, by George Neumeyer, Ph.D., 4to, Mannheim, 1869, p. 145. See too his *Stations*, 117–121, 132 and 218.

Pl. II p. 9

DIAGRAM SHOWING THE MEAN DIURNAL CURVES OF MAGNETIC DECLINATION FOR FIVE SUMMER MONTHS, MAY TO SEPTEMBER INCLUSIVE, ON THE AMERICAN CONTINENT. SCALE 10′ = 1 INCH. THE SHADED MARGIN TO THE MEAN LINES SHOWS THE MEAN IRREGULAR FLUCTUATION AT THE SAME HOURS.

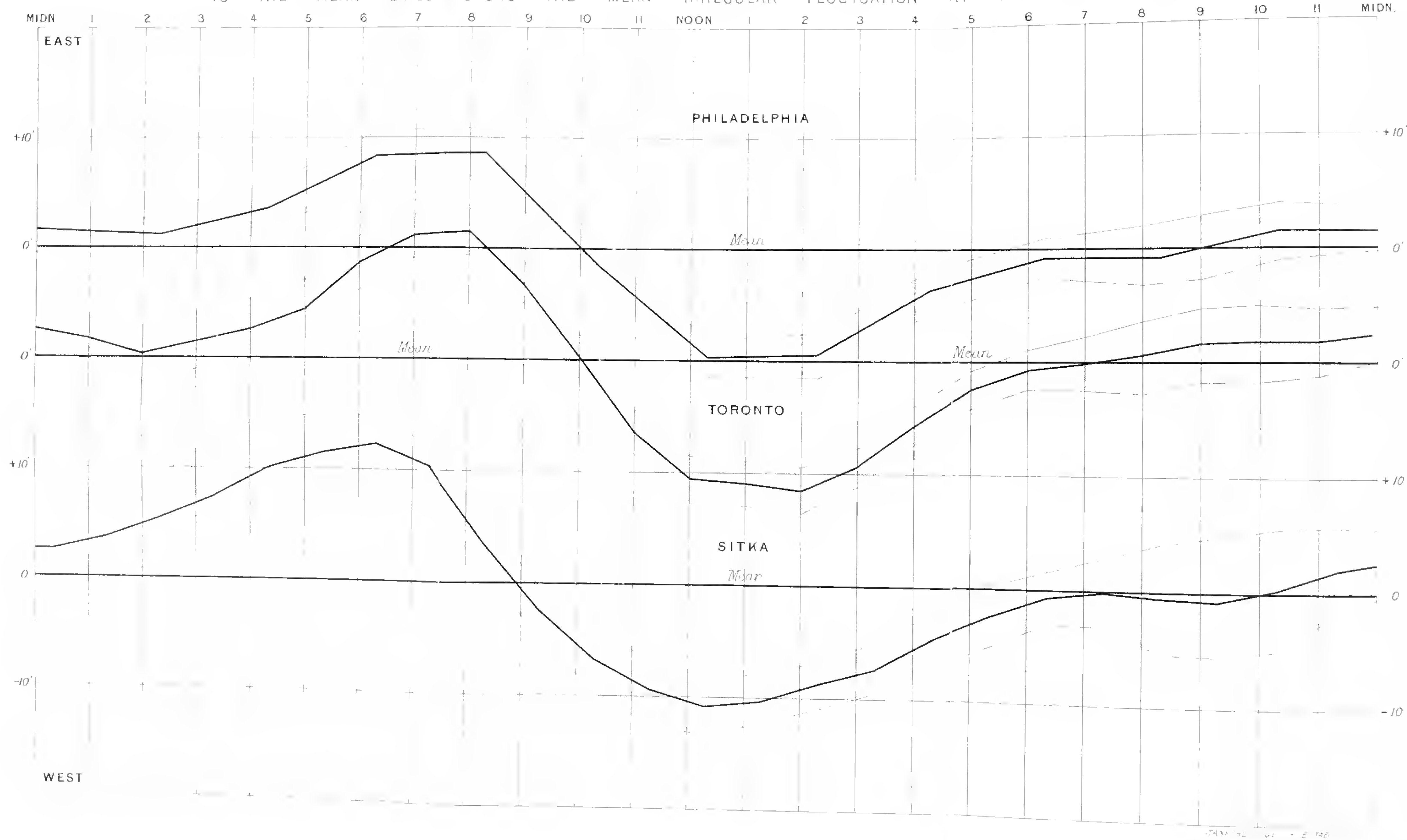
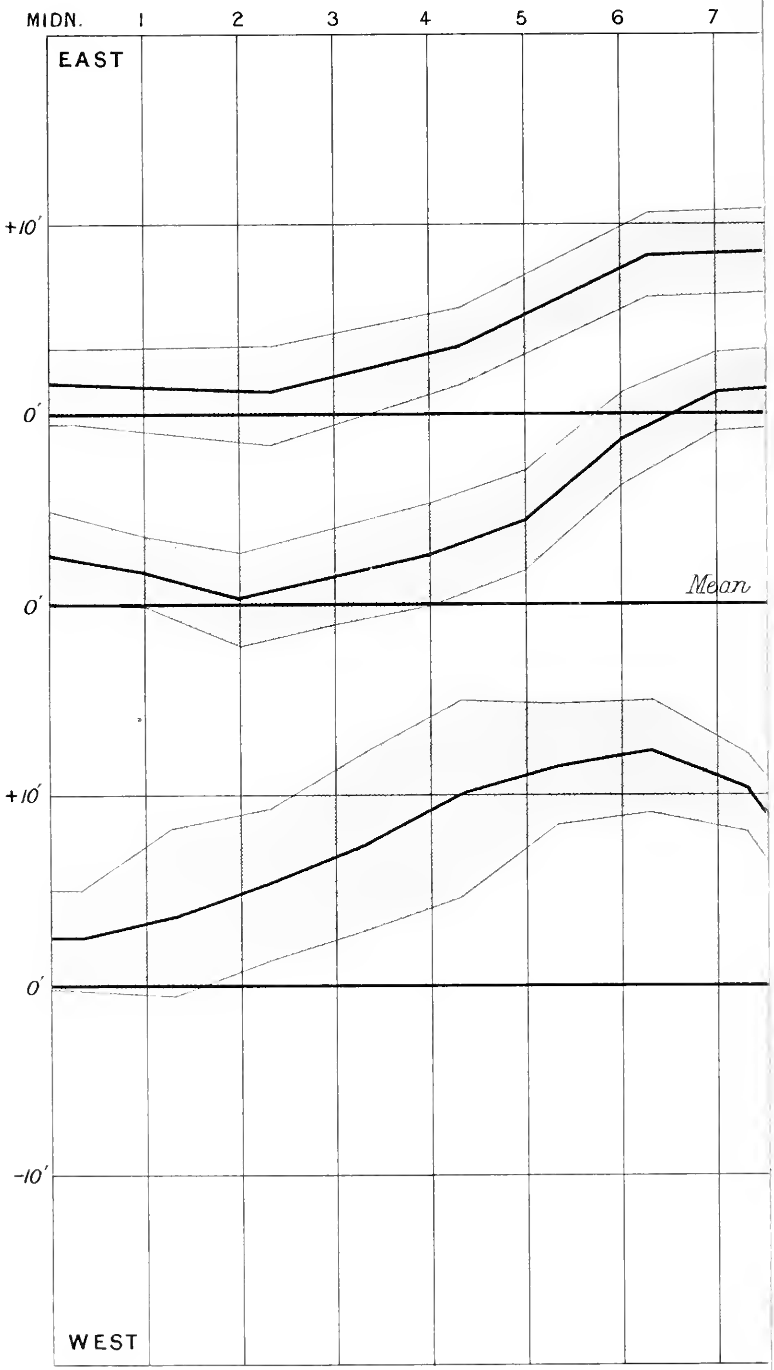


DIAGRAM SHOWING THE MEAN
MAY TO SEPTEMBER INCLUSIVE,
TO THE MEAN LINES.



The greater part of my observations of variation were made in the forenoon, with the sun from three to five hours distant from the meridian: a great many, however, were made in the afternoon, and it is obviously necessary for very accurate determination that a correction for the diurnal movement between these periods of the day should be applied; but I am not aware of any date upon which the amount of such correction can be even approximately assigned. As I have already remarked, we do not know at present the mean diurnal movements of the horizontal needle in the summer months for any station in the northern regions of the American continent, except Sitka, in Alaska, on the Pacific coast,[1] where they are subject to the same irregular influences as were found to prevail at Lake Athabasca, and where the most easterly movements occur as early as 4 to 6 A.M. Still less do we know of the irregular fluctuations, beyond the fact that they are of frequent occurrence and of large amount.

We will, however, examine the facts as far as known.

First, with regard to the mean diurnal movements. I take the hours of 8 A.M. and 3.30 P.M. for comparison, being good representative hours of observation for travellers. The first is at Toronto and in middle latitudes generally, about the time of the most easterly deviation of the north end of the needle. That is to say, easterly variations are then at their *maximum*, and westerly variations at their *minimum*. The second is beyond the turning-point of most westerly deviation (which occurs about 1 P.M.), and the needle is about half-way back to its mean position, which it repasses about 7 P.M.

The annexed Plate shows the mean diurnal movements of a horizontal needle at each of three American stations during the summer months, or for the ordinary season of travelling, namely, from May to September inclusive, and I have added the range of the mean disturbance of the declination for each hour, indicated by the shaded margin to the mean curves.[2]

The stations were:—

[1] See *Annuaire Magnétique et Météorologique, etc.* Par A. T. Kupffer. St. Petersburg, 1845.

[2] Extracted from a paper by the writer, *On the Irregular Fluctuations of the Magnetical Elements*, printed in the *Proceedings of the American Association for the Advancement of Science* for 1851. The numerical values will be found in the Appendix.

75° 10′ 44″ *Philadelphia.*—Lat. 39° 58′·3, long. $5^h\ 0^m\ 42^s{\cdot}9$; distant from the magnetic pole,[1] 1,917 miles. The times of observation being regulated by Göttingen mean time, $39^m\ 46^s$ E. of Greenwich, fell $19^m\ 30^s$ after the civil hours named.

79° 23′ 15″ *Toronto.*—Lat. 43° 39′·4, long. $5^h\ 17^m\ 33^s$; distant from the magnetic pole, 1,659 miles. Times of observation $2^m\ 21^s$ after the hours named.

135° 17′ 12″ *Sitka.*—Lat. 57° 2′·9, long. $9^h\ 1^m\ 8^s{\cdot}8$; distant from the magnetic pole, 1,355 miles; from Fort Chipewyan, 780 miles, and from Fort Simpson, 460 miles. Times of observation, $19^m\ 5^s$ after the hours named.

Taking then 8 A.M. and 3.30 P.M. as hours fairly representing the usual times of observation, the deviation of the compass needle from its mean position in the several months of the year is as follows. Each quantity for Philadelphia, Toronto, and Sitka is the mean for the years 1843 and 1844, which were years of minimum sun spots, and in which the movements were of less than an average amount.

TABLE.

Comparison of Diurnal Movements for the several Months of the years 1843–1844.

Month.	8 A.M. Deviation, Easterly				3.30 P.M. Deviation, Westerly			
	Ph.	To.	Ska.	Aa.	Ph.	To.	Ska.	Aa.
January	2′·0	2′·1	0′·4	4′·0	1′·2	2′·2	0′·7	4′·4
February	1·9	2·6	−0·1	5·6	1·2	1·9	0·8	5·1
March	2·7	4·3	0·9	—	2·5	3·5	3·0	—
April	3·4	4·0	1·1	11·8	3·1	3·9	3·6	11·9
May	4·0	5·1	3·2	9·4	3·0	4·1	3·5	9·4
June	4·4	5·4	3·6	—	3·4	3·7	3·7	—
July	4·6	6·0	2·3	—	3·8	4·3	3·6	—
August	4·9	6·1	0·4	—	2·6	3·3	2·5	—
September	3·2	4·0	−1·1	—	1·5	2·7	1·7	—
October	2·5	2·6	−0·1	3·8	0·7	1·7	0·9	6·0
November	1·6	2·1	−1·2	3·8	1·1	1·6	0·7	3·3
December	1·4	1·4	−1·0	1·9	1	1·8	0·2	3·8

Thus it appears that in comparatively low latitudes, such as that of Toronto, an A.M. and P.M. observation in the summer months will differ about 10′, and in high latitudes, such as that of Fort Chipewyan, on Lake Athabasca, or Fort Simpson, by a considerably larger quantity.

[1] In latitude 70°, longitude 96° W. (James Ross, 1831).

The easterly extremes at Sitka, on the Pacific, fall nearly two hours earlier than they do in the interior of the continent, and although not less in amount, but rather greater, they do not influence the usual hours of observation so much.

The late afternoon is preferable to the early morning for a traveller's observations of variation, not only because the element itself differs less from the mean, but also because the disturbing influences are less active.

I observed the movements of the declinometer *en route* upon many occasions for longer or shorter periods, and also, as my instructions required, observed the Göttingen term days whenever it was practicable, and these have all been plotted down. Taking the stations in the order of remoteness from Toronto, the following notes give the results as to correspondence of movement:—

Sault St. Marie.—November 4 and 5, 1844. From Toronto 282 miles. A well-marked movement of declination and horizontal force, the former measures 9′·3 at Toronto and 44′·4 at the Sault, but the epochs correspond: min. about $6^h\ 38^m$, max. 13^h Gött.

White River, Lake Superior.—October 21 to 26, 1844, during detentions, including the term day of October 23–24. Distance from Toronto 402 miles.

A well-marked easterly movement occurred between $21^d\ 3^h$ and $21^d\ 21^h$, Gött. The first westerly extreme was, at Toronto, at $21^d\ 4^h$, but not until $21^d\ 7^h$ on Lake Superior. The easterly extremes coincide at $21^d\ 15^h$. The second westerly extreme was at 20^h at Toronto and $20^h\ 30^m$ on Lake Superior. Range at Toronto, 13′·4; at White River, 31′·9.

Also an easterly extreme at $14^h\ 30^m$ to 15^h, Gött., and a westerly extreme at 20^h at both places. Range at Toronto, 13′·3; at White River, 30′·8.

A well-marked easterly movement prevailed at both places between 12^h and 13^h of Gött. mean time on the 23rd. A well-marked westerly movement between 18^h and 19^h: range between the limits, at Toronto, 13′·9; on Lake Superior, 27′·2. The epochs are nearly coincident.

Fort William, Lake Superior.—October 11 and 12, 1844. Distant from Toronto, 503 miles. Half-hourly readings were taken from $11^d\ 4^h$ to $12^d\ 6^h$., Gött.

An easterly extreme occurred from $12^d\ 2^h$ to $12^d\ 4^h$, Gött., and a westerly extreme about $12^d\ 6^h$ marked at both stations. Range at Toronto, 10′·9; at Fort William, 40′.

Winnipeg River.—Distant from Toronto 751 miles. Term day of June 21–22, 1843. A certain degree of correspondence is observable in the movements between $21^d\ 14^h$ and $21^d\ 17^h$, which are not very marked at either station; but there is no trace at Toronto of a bold westerly movement of 30′ between $22^d\ 4^h\ 30^m$ and $22^d\ 5^h$, or of several other well-marked movements of less magnitude at the northern station. The magnitude of shock, as is well known, is no guide to its geographical range.

Jack River.—The Long Portage. Distant from Toronto, 904 miles. Term day of July 19-20, 1843. A continuous westerly movement, broken by minor oscillations, lasted from $20^d\ 1^h$ to $20^d\ 8^h\ 10^m$, Gött.; about the same time a westerly movement set in at Toronto, but reached its limit somewhat earlier, at $7^h\ 20^m$; the magnet steadily moved east. Range at Toronto, 11′·8; at the Portage, 1° 53′. The difference of turning point is well marked.

York Factory, on Hudson's Bay.—Distant from Toronto, 940 miles, July 26, 1843. A state of disturbance prevailed nearly all day. The observed range of declination was 2° 13′; no disturbance was observed at Toronto, and the recorded readings only show a range of 16·3.

Fort Chipewyan, Lake Athabasca.—Distant from Toronto, 1,478 miles; from the magnetic pole, 780 miles. Term day of October 18–19, 1843. A bold easterly movement commenced at $18^d\ 15^h$, turned at $15^h\ 40^m$, and reached its westerly limit about $16^h\ 40^m$. This movement is conspicuous both at Greenwich and at Toronto, and a secondary westerly oscillation at 16^h is as well marked at Toronto as at the Fort; it is even perceptible at Greenwich. Here, then, we have a shock traceable over a third of the northern hemisphere. The range was at Lake Athabasca 1° 2′·4, at Toronto 17′·5, at Greenwich 10′·3. There was another movement from $19^d\ 5^h$ to $19^d\ 6^h$, Gött., in which correspondence may be traced; while, on the other hand, Greenwich had a movement of 5′, from $19^d\ 8^h$ to $19^d\ 9^h$, which is sufficiently well marked, and is absent in the American traces.

I may add that on this occasion the same degree of correspondence occurs in the changes of horizontal force, but with a remarkable difference of epoch. The shock, accompanied by rapid increase of force, is shown at Toronto at $15^h\ 5^m$, at Greenwich at $15^h\ 30^m$, at Lake Athabasca at $16^h\ 35^m$, and the maxima are: at Toronto at $15^h\ 35^m$, at Greenwich at $16^h\ 30^m$, at Athabasca at $17^h\ 10^m$. On the other hand, a large movement, between $19^d\ 5^h$ and $19^d\ 8^h$, which is also common to all three stations, is nearly coincident as to the turning points.

At the same station.—Term day of November 24–25, 1843. A well-marked movement at $24^d\ 13^h$, Gött., shown at Greenwich and at Toronto, is wanting at Athabasca; a second movement at Toronto at $14^h\ 15^m$ is wanting at both the other stations. A bold, easterly movement at Athabasca from 18^h to 19^h occurs in the contrary sense at Toronto, but is wholly wanting at Greenwich; another from $22^h\ 20^m$ to $23^h\ 40^m$ is wholly wanting at both Toronto and Greenwich.

The same station.—Term day of December 20–21, 1843. A small but well-marked movement at Greenwich at $12^h\ 25^m$ is wholly wanting at Toronto and Athabasca. Well-marked movements at Athabasca between $16^h\ 20^m$ and 18^h can be barely identified at Toronto, and produce only a small undulation at Greenwich, which, however, I am disposed to identify with the same shock.

The same station.—Term day of January 24–25, 1844. A high degree of disturbance prevailed. The principal movement of declination occurred between $16^h\ 30^m$ and 18^h, and is to be identified at Toronto and at Brussels; it is remarkably prominent at Sitka, but a little later. On the other hand, enormous movements between $24^d\ 21^h$ and $25^d\ 4^h$, common to Athabasca and Sitka, are entirely absent from the European traces, and have but a moderate degree of answering movement at Toronto—enough, however, to show that the disturbance embraced that station.

The same station.—Term day of February 23–24, 1844. A moderate disturbance lasting from $24^d\ 4^h$ to $24^d\ 8^h$ at Athabasca is perceptible at Toronto, but with no correspondency in the movements.

Fort Simpson, on Mackenzie River.—Distant from Toronto, 1,827 miles; from the magnetic pole, 781 miles. Disturbance in April 1844, from $16^d\ 19^h$ to $17^d\ 12^h$, Gött. This disturbance apparently set in about the same time at both stations, and the most violent movements occurred between $16^d\ 20^h$ and $17^d\ 3^h$ at both, but there is no resemblance of detail; and a shock which threw the magnet no less than 6° 40′ to the eastward at Fort Simpson, at $17^d\ 1^h\ 24^m$, is not apparent at Toronto at all. This magnetic disturbance was one of the most remarkable on record. It embraced both hemispheres. The force began to return to its normal value about 2^h or $2^h\ 30^m$ earlier at Toronto in Gött. time than it did at Fort Simpson. The difference of longitude being about $2^h\ 8^m$, this appears to connect the movement with that of the sun.

At the same station.—Term day of April 24–25, 1844. A very bold easterly shock at Fort Simpson, from $25^d\ 1^h\ 30^m$ to $25^d\ 4^h\ 20^m$, Gött., coincides exactly in epoch with a westerly movement at Toronto, but the range was in one case about 2° 54′, in the other only 10′·1. The trace at Sitka closely resembles that at Fort Simpson. There is a similar agreement of epoch in great changes of the horizontal force, but without close agreement of actual time. Toronto is again about 1^h the earlier in two maxima, but later in two others.

At the same station.—Term day of May 24–25, 1844. A conspicuous movement to the eastward at $24^d\ 12^h\ 15^m$ at Toronto precedes by about 10^m only, one which appears to correspond with it at Fort Simpson. On the other hand, large movements at Fort Simpson, especially one about $25^d\ 2^h$, Gött., have no answering shock at Toronto.

This comparison might be extended much further; but the examples adduced are sufficient to prove that the regular observations at a fixed observatory like that of Toronto can be of no service to a traveller for the correction of his absolute variations, beyond a very moderate range of distance. Even when shocks coincide in time, they bear no definite relation in magnitude.

8. *Magnetic dip.*

The dips observed are comprised between 69° and 83°. The instrument was a nine-inch circle, by Gambey, of Paris, the property of the late Admiral Fitzroy, R.N., the same which had been employed a few years previously in the magnetical survey of the British Islands; besides which I carried a seven-inch Fox's dip circle, which was commonly used only for determining the relative force, and its results of inclination were not made use of. Since, however, it is of great importance to corroborate certain irregular values by those of a second instrument and a second observer, so as to have good grounds for attributing them to local disturbing force, I have now added in some cases the approximate dips by

Fox. The poles of Gambey's needles being reversed each time (with only four early exceptions), the results are obviously more to be relied on than those obtained with needles which cannot be reversed. It will be seen, however, in the next section that the Fox instrument gave generally results which are within moderate limits of error.

The observation was usually limited to one complete determination with needle No. 1, consisting of four or five readings of both ends of the needle in each of the usual four positions, before reversing the poles, and as many afterwards. The degree of reliance to be placed upon the dip thus ascertained will be seen on comparing the results by needle No. 2 when observed at the same time and place, as subjoined.

Table II.

Comparison of the Dips given independently by two needles, at certain stations.

No.	Date 1843–4	Station	Dip		Half difference
			G. 1	G 2	
34	Apr. 20	Williamsburg	76° 31′·2	76° 29′·0	1′·1
LXIX.	May 29	Fort William	78 9·7	78 10·4	0·3
CXIII.	July 3	Fort Garry	78 19·4	78 16·3	1·5
CXXXI.	July 10	Lake Winnipeg	80 3·7	80 7·2	1·8
CXXXVI.	July 12	Norway House,	81 11·0	—	—
—	July 13	"	—	81 6·2	2·4
CLXII.	July 24	York Factory	83 50·5	83 44·0	3·2
CLXXXIII.	Aug. 24	Cumberland House	80 28·8	80 31·8	1·5
CCXI.	Sept. 9	Isle à la Crosse	80 9·1	80 10·5	0·7
CCXXIX.	Sept. 30	Fort Chipewyan	81 37·7	81 37·5	0·1
CCXCV.	May 10	Fort Simpson	81 41·5	81 50·7	4·6
CCXCIII.	May 29	Fort Good Hope	82 55·8	82 56·1	0·1
CCCVII.	June 22	Fort Resolution	82 43·5	82 45·4	1·0
CCXLII.	July 11	Fort Vermillion	80 48·4	80 47·6	0·4
CCLX.	July 22	Dunvegan	78 45·7	78 46·8	0·5
CCLXIV.	Aug. 3	Lesser Slave Lake	78 36·2	78 41·9	2·8
CCLXXVII.	Aug. 11	Fort Assiniboine	78 16·9	78 13·5	1·7
CCLXXX.	Aug. 17	Edmonton	77 53 4	77 55·1	0·8
CCLXXXVI.	Aug. 22	Fort Pitt	78 43·0	78 39·1	2·0
CCLXXXIX.	Aug. 26	Carlton House	78 30·2	78 31·2	0·5
CLXXXIII.	Aug. 29	Cumberland House	80 20 5	80 19·0	0·7
CXXXVI.	Sept. 7	Norway House	81 11·1	81 11·4	0·1
CIX.	Sept. 19	Fort Alexander	79 3·4	79 2·5	0·4
XC	Sept. 30	Fort Francis	77 41·4	77 44·5	1·6
LXIX.	Oct. 11	Fort William (1)	78 7·5	—	—
—	"	" (2)	77 55·5	77 55·5	0·0
LXI.	Oct. 17	Pic Fort	78 32·8	78 30·1	1·3
LX.	Oct. 21	White River	78 33·7	78 32·5	0·6
LIII.	Oct. 30	Michipicoton	78 8·1	78 8·5	0·2
XLIX.	Nov. 4	Sault St. Marie	77 46·2	77 45·6	0·3
XL.	Nov. 8	Fort La Cloche	76 50·7	76 49·7	0·5
XXXIV.	Nov. 14	Penetanguishene	76 19·2	76 21·0	0·9

The half difference between the two values of the dip, being the difference of each from the mean of both, is by the foregoing table:

	Under 1′	17 times.
Over 1′	„ 2′	8 „
„ 2′	„ 3′	3 „
„ 3′	„ 4′	1 „
„ 4′		1 „

The last difference is probably attributable to disturbance.

The result is to show that much reliance may be placed upon a single determination of dip, which enters into so many deductions of the force from angles of deflection with Lloyd's static needles, and from the times of horizontal vibration of magnets.

I observed a series of dips at the Royal Military Repository, Woolwich, with needle No. 2 before leaving England in 1842 and again after my return in 1846. The results are as follows:—

1842. *Needle Gambey, No.* 2.

		° ′
1842, May	27, A.M.	68 59·2
„	27, P.M.	69 1·5
„	28, A.M.	69 1·9
„	31, A.M.	69 5·9
„	31, P.M.	69 2·5
June	1, A.M.	69 5·2
„	1, P.M.	68 59·2
„	1, P.M.	69 0·4
	Mean	69 2·0

The probable error of a single observation of this set is 2′·87 and the probable error of the mean is 0′·59.

After return to England:—

1846. *Needle Gambey, No.* 1.

		° ′
1846, June	8, A.M.	68 58·6
„	9, A.M.	69 1·0
„	11, A.M.	68 56·8
„	12, A.M.	69 3·2
	Mean No. 1	68 59·9

Needle Gambey, No. 2.

		° ′
1846, June	8, A.M.	68 52·0
„	10, A.M.	68 55·7
„	11, P.M.	68 56·3
„	12, P.M.	69 1·3
	Mean No. 2	68 56·4

The probable error of a single observation of this set is 4′·37, and the probable error of the mean is 0′·74, being rather greater than before.

I was favoured by Sir G. Airy with the dips observed at Greenwich during the month of June 1846, the Observatory being only two and a half miles east of the R. M. Repository. The mean is 68° 58″·1, showing that the foregoing results, although less uniform than could be wished, and although the instrument doubtless by this time wanted readjustment, are correct; with the greater dip of high magnetic latitudes, the error of individual results diminishes.

9. *Relative Magnetic Force.*

Unlike the variation and the dip, which are matters of direct observation, the relative amount of the magnetic force at any given spot, as compared with its value at some other place, can only be *inferred* from the observations, after careful estimation of changes of condition capable of affecting the result. First of these is a variation in the magnetic state of the needle employed. Needles commonly lose their magnetism, not always regularly or uniformly, and their magnetism depends upon their temperature. The early observations of Humboldt, those of Franklin, and of Sabine down to 1823, were made by counting the vibrations of a dipping needle brought to rest by the earth's magnetic force, a method attended in practice with so many difficulties that it has long been completely abandoned. In the method I was instructed to employ, the variable force of the earth's magnetic attraction was weighed, so to speak, against the force, assumed to be invariable, of its attraction of gravitation, in one of two ways.

Lloyd's method.—The needle was an ordinary dipping needle adapted to Gambey's circle, but perforated with three small holes in the southern limb, intended for the insertion of a minute counterpoise of copper (three of these were supplied, weighing respectively 0·5, 0·6, and 1·0 grain), by which it is brought to a position nearly at right angles to the line of dip, that being the position in which the resulting value of the force will be least affected by the friction of the axle on its supports. I find in the Irish survey that the readings ranged from −5° to −17°, giving angles of deflection ranging from 77° to 86°.[1] In some preliminary observations at the Repository, Woolwich, July 6, 1842, dip 69° 1′·9, therm. 59°, a

[1] See *Lloyd's Miscellaneous Papers*, 1877, p. 194, and *Fifth Report of the British Association*, 1836.

weight of 0·60 grain in needle A gave an angle of deflection from the line of dip.

In the first hole of		63° 0′
,,	second ,,	83° 27′
,,	third ,,	101° 35′

As each needle has its personal history, I will complete that of needle A before referring to the other.

10. *Needle A, or* 1. *Coefficient for temperature*, $q = 0{\cdot}000016$.[1]

At Quebec, on September 1, 1842, where the dip was 77° 15′·3, thermometer 70°, and the relative total force as 1·829 to 1·372, or as 1·344 to unity at Woolwich, the weight of 0·60 grain, as used above, proved to be insufficient. Tried in the third hole it only gave a deflection of 54° 55′; two half-grain weights were then tried, namely, one in the first and one in the second hole, which gave too large an angle (127° 47′), and lastly, 1·0 grain in the first hole, which gave too small an angle (44° 25′[2]). None of these weights being suitable for the American intensities, I subsequently obtained weights of 0·7 and 0·8 grain from the mint at Philadelphia. In point of fact, the absolute amount of the weight used is of no consequence, and I ought to have got a piece of copper wire and filed it until it brought the needle to the required reading of −12° or −13°.

This method of determining relative intensity, which was first employed by the late Professor Humphrey Lloyd in his magnetic survey of Ireland in 1835, was then new and unfamiliar to me, and I did not, while in England, appreciate sufficiently perhaps the importance of profiting by his ever-ready instruction.

Needle A was used with a weight of 0·8 grain in the middle hole at twenty-four stations, ending May 29 at Fort William, which had to be taken as a base for that series, in consequence of the loss of force since leaving Toronto (*ante*, p. 2). The total angle of deflection having diminished from 92° at Montreal to 87° at Fort William, bringing the south end of the needle close to the lifting frame, I thought it expedient, looking to a further increase of

[1] Full particulars respecting these coefficients will be found in *Phil. Trans.*, 1846.

[2] I find a subsequent query against this value, which appears too little. It does not enter into any result.

force, to shift the weight to the last hole, by which the angle was augmented to 95°. This formed the basis of a second series. It was used with 0·8 grain in the last hole, at fifteen stations, ending at the Rat Portage, Lake of the Woods, where the instrument was thrown down, and one of the arms of the axis of the needle slightly bent; but this was partially set right at Fort Garry, and a third series of observations made at twelve stations, extending to York Factory. On trying it, however, on August 15 at the Grand Rapid of the Saskatchewan, I found it impossible to get any satisfactory results, although nothing had appeared amiss on the previous day, and the needle A was henceforth laid aside. It was used in all at forty-nine stations, referred to Fort William and Norway House as bases.

11. *Lloyd's Needle B, or 2. Coefficient of temperature,* $q = \cdot 000050$.

A weight of 0·6 grain in the first hole gave at the Repository, Woolwich, on July 5, 1842, therm. 63°, dip 69° 1′·9, a deflection of 92° 21′; with two the same weight at Quebec, on September 1, therm. 70°, the angle of deflection was, owing to the increase of force, only 42° 32′·1. On shifting the counterpoise to the third hole, therm. 73°, it became 103° 22′·7. It was used with this weight at six stations in Canada, which are included as to dip in Table XLIX-L, but were omitted by Sabine from his abstract of intensities, Table XXVII, probably from the loss of magnetism of the needle, and I omit them for the same reason.

The counterpoise (0·6 grain) was shifted at Montreal on April 25, 1843, to the centre hole, and was so used until my arrival at Fort William, the angle of deflection having decreased from 88° 6′ to 81° 36′, and the S end of the needle being now behind the frame for lifting it off its agates, the counterpoise was here shifted, on May 29, to the third hole, and the angle of deflection became 112° 13′·5, being increased no less than 30° 37′·8. This was too much, and I should have done better to have filed the counterpoise down a little; but I was not free from a notion that the weights must remain untouched. The weight remained the same until my arrival at York Factory on July 24, when the large increase of the angle of deflection, now more than 134° (90° + 44°) made me substitute a new counterpoise, the value of which was not ascertained, by which it was reduced to 64° 48′ (90° − 25° 12′). This was used in returning over the same ground to Norway House, which is the base of two series, the one extending from Fort William to Norway House, and thence to York Factory, the other extending from York Factory to Norway House on my return. After completing the observations at Norway House on this second occasion, the mean angle of deflection being found to be only 67° 48′ at this station, I reverted to the arrangement in use from Fort William to York Factory; that is to say, the counterpoise used from Montreal to York Factory was restored to its place (viz. 0·6 grain in the third hole), giving an angle of 106° 54′ at therm. 63°, which became the base of a fourth series with this needle, extending to Lake Athabasca.

Sabine showed much patience and skill in getting available results out of these broken series, but I candidly admit and regret their imperfection, which was partly caused by the unsuitability of the method for determining so great a range of intensity, with the high dip that prevailed. The values range from 1·800 to 1·878, or as unity 1·043. In Dr. Lloyd's observations in Ireland the range of force is from 0·9953 to 1·0166, or as unity to 1·023, and of the angle of deflection from 76° 56′ to 84° 55′.[1]

Two new Lloyd's needles were forwarded to me in 1844 and received at Norway House. They proved to be about 0·2 inch too long for the dip circle, and were never used. A third pair distinguished by Sabine as L.C and L.D were received in 1845 and employed by Lieutenant Younghusband at five stations, and by myself at seven stations. The temperature corrections were duly ascertained and applied.

On any repetition of these observations it will, I think, be found possible, by taking La Cloche or Sault St. Marie as the base station, with weights adjusted to give readings of −13° or thereabouts, to cover the whole ground with one series, provided the needles retain their magnetism unaltered.

The following example illustrates the use of these needles:

[1] Extract from the magnetic survey of Ireland:—

At Carlingford, Dip .	71° 28′·2	At Gorey, Dip	70° 53′·8
Angle	− 5° 27′·5		− 14° 1′·1
Total deflection . .	76° 55′·7		84° 54′·9
Intensity to Dublin as unity	1·0166		0·9933

See *Fifth Report of the British Association*, and *Lloyd's Miscellaneous Papers connected with Physical Science*, 1877, p. 203.

12. *Example of reduction with Lloyd's needles.*

Let δ = the dip at the station

θ = angle of inclination of the needle to the horizon when loaded.

Then the force $\phi = \frac{\beta \cos \theta}{\sin(\delta - \theta)}$, where β is a constant.

Example.—Needle A.—Fort William (Station LXIX) being adopted as the base, observed there on May 29, 1843. $\delta = 78° 10'·0$ mean angle of deflection of Lloyd's static needle A, with a weight of 0·6 grain in the middle hole, $-$ 9° 39′·4, Th. 63°. Then $(\delta - \theta) = 87° 49'·4$.

θ_1 =	$-$ 9° 39′·4 = .	log cos	9·993802
δ =	78° 10′		
$(\delta - \theta_1)$ =	87° 49′·4 .	. log sin	9·999686
			9·994116

At St. Helens, Montreal, April 29, observed $\delta = 77° 5'·3$, mean angle of deflection with the same weight $-$15° 6′·1, Th. 56°. Then $(\delta - \theta) = 92° 11'·4$.

θ =	$-$ 15° 6′·1 = .	log cos	9·984737
δ =	77° 5′·3		
$(\delta - \theta)$ =	92° 11′·4 = .	log sin	9·999682
At St Helens			9·985055
At Fort William			9·994116
Relative Force $\frac{\text{St. Helens}}{\text{Fort William}}$ . .			9·990939 = 0·9793
But the force at Fort William is 1·8601 (*see* Station LXIX)			0·269536
Therefore at St. Helens			0·260475 = 1·8217 as observed.
This is to be corrected for a difference of temp. of + 7° $1-(t-t_1)\ q$ = 0·999888			9·999951
Finally force at St. Helens . . .			0·260426 = 1·8265[1] as reduced.
To convert this into Absolute Scale Multiply by the ratio $\frac{13·896}{1·836}$ . .			0·879017
On the Absolute Scale . . .			1·139453 = 13·786.

[1] Sabine by inadvertence included in his Table XXII two stations, Williamsburg and St. Helens, that are out of place. Williamsburg, April 20, belongs to an earlier series, St. Helens appears in Tables XXI and XXII, with two different results for the same date, viz. Table XXI, April 25, intensity 1·812, which also belongs to the earlier series, Table XXII, April 25, intensity 1·831, the mean of which appears to be given as 1·821 in Table XXVII. The later date should be April 28, when the counterpoise was shifted from the last hole to the centre hole, to diminish the angle, and both stations should be taken out of Table XXII.

The expectation entertained that Lloyd's method would give better results than Fox's was not borne out by my experience. Each has its advantages and its disadvantages; but the simplicity of the former, and its less liability to instrumental derangement, would probably give it a preference, if a greater number of needles than two were supplied. Sir E. Sabine's opinion was expressed as follows:—

'I expect that you will find Lloyd's intensity needles give you in *very high* latitudes more exact results than Fox's. You will require great exactness in the intensity in your journeys. Guided by Ross's observations in the S. Hemisphere, I am led to suppose that your most important ground for the intensity observations will be the strip of territory comprised between the 80th and 100th of W. longitude, and N. from the 40th parallel of latitude—that in 47° or thereabouts of latitude you will have 1·9 or thereabouts of intensity, and that in the great space from thence to 70° the changes will not go beyond 2·0 or 2·05. But it would be very desirable to ascertain where this maximum is situated; it will be found, as I have already said, between longitude 80° and 100°, and between 47° and 70° latitude. The line of the variation and the culminating points of the curves of dip and intensity will be found between these longitudes.[1]

'We shall be very glad to receive your first essay in observing disturbances with the Transportable.

'(*Signed*) EDWARD SABINE.'

October 14, 1844.

13. *Fox's Dip Circle.*

The dip circle of Mr. Robert Weare Fox was devised in 1834,[2] and used for the first time in any remote region by the late Captain Owen Stanley, R.N., in Back's Arctic voyage of 1836. Being especially for use at sea, it was much employed in the Antarctic voyages of Sir James Ross. I had myself observed with it daily in my voyage home from St. Helena, and enjoyed the great advantage of further practice and instruction from Mr. Fox himself, at his residence of Penjerrick, near Falmouth, in the same year. The instrument, as then turned out by George, of Falmouth, was very

[1] It was actually found in lat. 52 19′, long. 91° 59′ W. The writer had assigned, in his *Experiments to determine the Figure of the Earth* (1825, p. 489), lat. 60′ N. and long. 80° W., as the approximate position. The present conjecture, although not strictly accurate, is a remarkable evidence of advance in knowledge.

[2] See *Sturgeon's Annals of Electricity*, iii. 1839, p. 288.

perfect, but easily put out of order. The bearing points of the axles were minute cylinders of steel, resting in jewels like those of a watch. Each jewel consisted of two parts, a ring of ruby and a plane of ruby facing it. The rings were very apt to get broken, and their edge to be chipped in the operation of putting in the needle. In this way two sets were rendered unserviceable, the axles themselves were renewed three or four times before Mr. Fox was satisfied. This operation was performed by drilling out the old axle and inserting a piece of steel wire, which was afterwards turned true; I also carried a spare axle. Mr. Fox did not allow his needles to oscillate. The axle was made very nearly the gauge of the ring, and he considered that the friction should be sufficient to bring the needle to rest almost immediately. An ivory rubber was furnished, to be applied to the axle-carrier, by which a gentle vibration was set up, to assist the needle in finding its true magnetic direction. The needles were balanced with great precision, but as Mr. Fox himself pointed out, they were liable to small variations in the direction of their magnetic axis.[1]

I subjoin on the pages following a memorandum of results obtained with my instrument before and after its employment in the North-West.

The several results are collected below.

					° ′
I.	At Falmouth,	Dip ascertained by deflection,		Needle C .	68 58·7
II.	„	„	from angles with weights	„ .	68 50·7
III.	„	„	„ „	Needle A .	68 47·4
IV.	At Woolwich,		by weights	„ .	68 58·8
V.	„		by deflectors	„ .	69 10·4
VI.	„		„	„ .	69 1·0
VII.	„		„	„ .	68 58·5
VIII.	„		by weights	Needle C .	69 1·0
IX.	„		„	„ .	68 59·8
X.	„		„	„ .	69 4·0

These results show that with a new instrument the mean dip may be inferred from the angles of deflection, given when weights of 2 to 4 grains are applied, without serious error. The greatest difference is −11′·7, and if we take the dip at Woolwich as 69° 1′·9 (as given by observations with Gambey's circle) the mean by Fox only differs from it by 4′·5.

[1] 'I have continually observed that the magnetic axis of a given needle is liable to frequent variations, even without its having been retouched.'—*Sturgeon's Annals of Electricity*, iii. p. 297.

TABLE IV.

A. *Results with Fox's Dip Circle, before Travelling.*

Date		Thermometer	Weight or Deflection		Instrument facing	Actual readings	Partial	Means	Dip
		°				° ′	° ′	° ′	° ′
1842 June 29	Falmouth, Mr. Fox's Garden .	68	—	—	E.	—	68 59	69 5·0	
					W.	—	69 11		
	Needle C	68	—	N.	E.	109 9 28 54	69 15	68 59·2	
					W.	109 14 28 40	68 57		
		67	—	S.	E.	103 23 34 50	69 65	68 55·0	
					W.	103 0 34 27	68 43·5		
		66	1	Both	E.	124 15 13 57	69 6·0	68 55·7	
					W.	123 54 13 37	68 45·5		
	I. (*a*) Needle C, Mean Dip								68 58·7
	Angles with Weights.								
		16	—	gr. 20	E.	101 24 35 14·5	68 19·2	68 47·1	
					W.	102 19·0 36 11	69 15·0		
		66	—	3	E.	123 15 13 17·5	68 16·2	68 54·3	
					W.	124 18 14 47	69 32·5		
	II. (*b*) Needle C, Approximate Dip by Weights								68 50·7

June 30	Falmouth	60	—	2·0	E.	96 7	68 42·5	68 52·0	
						41 18			
	Needle A	—	—	—	W.	96 45	69 1·5		
						41 18			
				2·5	E.	103 53	68 43·0	68 41·0	
						33 33			
					W.	104 3	68 39·0		
						33 15			
				3·0	E.	113 2	68 51·5	68 49·2	
						24 41			
					W.	112 24	68 47·0		
						25 10			
	III. (*c*) Needle A, Approximate Dip by Weights								68 47·4
July 7 (1)	Woolwich	58·5	—	—	E.	—	69 14·8	69 7·5	69 7·5
(2)	Needle A	—	—	—	W.	—	69 0·3		
				2·0	E.	96 12	68 46·5	68 54·8	
						41 21			
					W.	96 37·7	69 3·1		
						41 28·5			
				2·5	E.	104 39·7	69 10·3		
						33 41			
					W.	*103 19·7*	*67 50·7*		
						32 21·8			
				3·0	E.	113 27·7	69 19·6	69 2·9	
						25 11·5			
					W.	112 20·9	68 46·2		
						25 11·5			
	IV. (*d*) Needle A, Approximate Dip by Weights								68 58·8
July 8 (1)	Woolwich	—	—	—	E.	—	69 13·7	69 13·2	
(2)	Needle A	—	—	—	W.	—	69 12·7		
				S.	E. at 40°	87 33·5	68 56·1	69 8·3	
						50 18·7			
					W.	87 46·7	69 20·6		
						50 54·5			

TABLE IV.—A. *Results with Fox's Dip Circle, before Travelling*—continued.

Date		Thermo-meter	Weight or Deflection		Instrument facing	Actual readings	Partial	Means	Dip
		°				° ′	° ′	° ′	° ′
1842 July 8	Woolwich (*continued*) . .	—	—	—	E. at 50°	85 33·7 52 32·0	69 16·5	69 9·6	
					W.	85 37·0 52 56·0	69 2·8		
	V. Mean Dip A								69 10·4
July 8 (3)	Intensity observations . .	60	—	N.	E.	108 24·7 29 37·7	69 1·2	69 3·4	
	Old deflectors	—	—	—	W.	108 28·7 29 42·7	69 5·7		
				S.	E.	101 32·0 36 18·0	68 55·0	69 0·3	
					W.	101 33·7 36 37·5	69 5·6		
				Both	E.	122 31·5 15 21·7	68 46·6	68 59·3	
					W.	122 50·7 15 33·5	69 12·1		
	VI. Approximate Dip by old Deflectors A (1)								69 1·0
July 8 (4)	New Deflectors . . .	—	—	S.	E.	103 11·7 34 26·5	68 49·1	68 54·5	
					W.	103 19·0 34 54·8	69 1·9		
				N.	E.	111 22·5 26 48·5	69 5·5	69 2·6	
					W.	111 10·2 26 49·5	68 59·8		
	VII. Approximate Dip by new Deflectors								68 58·5

July 8				Both	E.	125 59·7 11 55·2	68 57·4	69 5·9	
					W.	126 14·5 12 14·2	69 14·3		
	VIII. Approximate Dip by Deflection (A)								69 1·0
July 8 (1)	Woolwich . . . . Needle C	62 —	— —	2·0 —	E. —	102 13·0 35 58·7	69 5·8	69 5·6	
					W.	102 21·0 35 50·0	69 5·5		
				2·5	E.	111 47·0 25 13·7	68 30·3	68 55·1	
					W.	112 38·2 25 41·7	69 20·0		
				3·0	E.	124 6·2 13 33·5	68 49·8	68 58·6	
					W.	124 26·3 13 48·5	69 7·4		
	IX. Approximate Dip by Weights (C)								68 59·8
July 9 (1)	Observation repeated . .	—	—	2·0	E.	102 24·7 36 11·5	69 18·1	69 13·5	
					W.	102 31·5 35 46·5	69 9·0		
				2·5	E.	111 47·5 25 37·5	68 42·5	68 54·6	
					W.	112 17·2 25 56·2	69 6·7		
	X. Approximate Dip by Weights (C)								69 4·0

14. I now turn to the observations with the same instrument after travelling to Lake Athabasca and back.

TABLE V.

B. *Results with Fox's Circle on return.*

		Therm.	Weight	Face	Readings	Partial	Dip	Dip
1841	Toronto Observatory circle, standard Dip							75° 19′·0
Dec. 14	Needle A (1)	40°·6	gr. 2·5	E.	102° 45′·2 49 5·0	75° 55′·1	75° 33′·1	
		40·6	—	W.	102 6·5 43 16·0	75 11·2		
		40·7	3·0	E.	109 27·5 42 45·5	75 6·5	75 3·4	
		40·8	—	W.	108 16·2 41 44·6	75 0·4		
		40·6	3·5	E.	115 13·8 36 58·5	76 6·7	75 27·6	
		40·8	—	W.	114 14·2 35 22·8	74 48·5		
		40·6	4·0	E.	122 5·0 28 46·1	75 25·5	75 4·4	
		41·0	—	W.	121 23· 28 3·7	74 43·3		
		?	4·5	E.	130 32·0 21 48·1	76 10·0	75 51·6	
		?	—	W.	130 2·0 21 4·5	75 33·2		
	Needle A, with weights							75 24·0
	Needle C (1)	40·2	1·5	E.	94 45·0 55 22·0	75 3·5	75 26·0	
		40·4	—	W.	95 34·2 56 2·8	75 43·5		
		40·4	2·0	E.	103 2·5 48 17·7	75 40·1	75 41·1	
		40·4	—	W.	103 5·5 48 18·7	75 42·1		
		40·4	2·5	E.	109 47·2 40 14·9	75 1·0	75 21·1	
		40·4	—	W.	110 22·2 40 50·2	75 41·2		
		40·4	3·0	E.	118 52·2 31 43·7	75 18·0	75 20·4	
		40·6	—	W.	119 13·7 31 32·2	75 22·9		
		40·6	3·5	E.	129 14·2 21 26·0	75 20·1	75 18·0	
		40·6	—	W.	129 16·2 21 15·6	75 15·9		
	Needle C, with Weights							75 25·3
Dec. 17	Needle A *repeated*							75 22·8
Dec. 19	Needle C *repeated*							75 16·5

Needle A gives a dip 4′·8 too great. Needle C gives one 0′·9 too great, but it may be safely inferred from the above that there is sufficient coincidence between the mean position of the needle of Fox's instrument when deflected by weights, as it is in the observation for intensity, and the true angle of dip, to warrant the employment of these angles in checking the dip when otherwise determined, and especially to make the results available as corroborative evidence, when the dip by Gambey's circle indicates, by its exceptional amount, a local disturbing effect.

15. As further evidence I subjoin the results by both instruments at every station between Montreal and Fort William, except those at which, for want of time, the observation with Gambey's circle was not complete.

TABLE VI.

Comparison of Dip by Gambey and Fox.

Station	1843		Gambey	Fox	Difference
			° ′	° ′	′
XII.	May 6	Chat Falls	75 7·0	75 6·3	− 0·7
XV.	„ 7	Grand Calumet . . .	76 44·4	76 53·2	+ 8·8
XVI.	„ 8	Fort Coulonge . . .	77 29·7	A77 14·8 C77 18·6	− 14·9 − 11·1
XVII.	„ 9	Pointe Baptême . . .	77 19·1	77 23·2	+ 4·2
XVIII.	„ 10	Portage des Deux Juachims	77 3·8	76 57·8	− 6·0
XXII.	„ 11	Trou Portage . . .	77 24·4	77 11·2	− 13·2
XXIV.	„ 12	Little River . . .	77 28·5	77 39·6	+ 11·1
XXVI.	„ 13	Lac Grand Vase . . .	77 21·7	77 31·1	+ 9·4
XXXIII.	„ 15	Recollet Falls . . .	76 45·4	76 48·9	+ 3·5
XXXV.	„ 16	Pointe aux Croix . .	76 31·3	*not observed.*	
XXXVIII.	„ 17	Lake Huron . . .	77 5·6	77 10·4	+ 4·8
XLII.	„ 18	Snake Island . . .	77 5·5	76 57·0	− 8·5
XLVI.	„ 19	Tessalon Point . . .	76 59·3	77 4·8	+ 5·5
L.	„ 20	Pointe aux Pins . . .	77 13·4	77 12·1	− 1·3
LI.	„ 21	Pointe au Crêpe . . .	77 11·5	77 47·7	− 23·8
LIII.	„ 23	Michipicoton . . .	78 6·3	78 4·4	− 1·9
LVIII.	„ 24	Otter Island . . .	79 43·6	79 32·8	− 10·8
LXI.	„ 25	Pic Fort	78 45·8	78 40·8	− 5·0
LXIV.	„ 27	Terre Platte . . .	78 53·6	78 47·3	− 6·3
LXVIII.	„ 28	Pointe Tonnerre . . .	78 23·2	78 30·0	+ 6·8
LXIX.	„ 29	Fort William . . .	78 10·0	77 59·6	− 10·4
		Mean difference			+ 7·5

The anomalous dips given by Gambey on May 15 and 24, one in defect, the other in excess, are both supported by Fox, proving at once the fact of local disturbance, and the value of a check. The same will be found in many other cases.

16. Complete observations of dip with Fox's circle were made at nineteen stations in Canada and the United States by me, and at

five stations by Lieutenant Younghusband:[1] but the instrument was rarely so used in the North-West. The time available was generally only enough to obtain an observation for intensity. I relied for the dip on Gambey's circle.

The instrument was also furnished with a needle (B) expressly for reversal, for the same reason that use was not made of it, but I employed it at five stations for intensity.

The following notes from my observation book show some of the perplexities of a magnetic observer out of reach of skilled mechanical assistance.

'Norway House, August 9, 1843.

'Needle A worked with very tolerable freedom, not as a positively good one, but not as a positively bad one. The irregularity with the weight of 4·0 grains is what has been noticed at all recent observations, and seems due to a bruise on the axle.'

'The centering of the jewels appears to have got out of position. The levels were brought to good adjustment previous to the last observation. Needle B, supplied as a reversing needle, and not hitherto used, was suspended, and the following observation made, for the base of an additional series, commencing from this place.'

TABLE VII.

Therm.	Weight	Face	Readings	Partial Means		Dip
°	gr.		° ′	° ′	° ′	° ′
8·7	2·0	E.	106 39·5 56 1·5	81 18·0	81 19·2	
8·7	—	W.	105 23·2 57 12·8	81 20·5		
8·7	2·5	E.	111 14·4 48 53·5	80 18·9	80 45·3	
8·8	—	W.	112 38·6 49 44·8	81 11·7		
8·8	3·0	E.	119 1·5 41 49·7	81 57·8	81 11·7	
8·8	—	W.	120 47·3 43 8·5	80 25·6		
8·8	4·0	E.	136 0·0 22 37·3	79 18·6	80 23·5	
8·8	—	W.	138 12·5 24 44·3	81 28·4		
Mean Dip by Weights						80 54·9
The Mean Dip by Gambey was						81 8·8

'Needle *B* did not work freely. It ceased to vibrate almost instantly, and although the readings with the jewelled arm in

[1] Table XLIX in *Phil. Trans.*, 1846.

various positions did not differ much, in one or two of them, for example, with 4·0 grain weight, face W., the friction of the jewelled arm appeared to command the position of the needle.'

'Needle *C* was again tried. It was very irregular, and moved with the arm, settling in positions 2° or 3° apart. I, therefore, condemned the axle, and substituted a spare axle for it.'

With this axle the needle performed pretty well, and I used it at twenty-six stations.

The results with needles *B* and *C*, which have not before been published, are here included. Sabine made use of the latter only so far as to check the value given for Norway House by needle *A*. We are concerned, however, to ascertain the relative force of the earth's magnetism at points widely apart. The difference is in quantity minute. Its determination is a matter of delicacy, and the more evidence producible the more satisfactory must be the conclusion. Individual results may be more or less affected by instrumental imperfection; nevertheless if the method is unexceptionable, the relative force ought to come out the more clearly from multiplied measurements; and so in fact it does, with the further advantage, already alluded to, that results of local irregularity are confirmed. Of this, Stations CXCIV, Little Rock Portage, and CCXXV, Pierre au Calumet, are remarkable examples.

17. Needle *A* preserved its magnetism unchanged throughout the survey, the angles of deflection by given weights being very nearly the same at Toronto in December 1844 as they were in January 1843. Thus:—

Weight	January, 1843	Temperature	December, 1844	Temperature
	I.		II.	
grs.	° ′	°	° ′	°
2·0	21 13·0	46	— —	36·5
2·5	27 2·3	—	26 46 7	—
3·0	33 8·7	—	33 10·4	—
3·5	39 27·0	—	39 15·2	—
4·0	46 45·9	—	46 40·5 [1]	—
4·5	— —	—	54 29·3	—

The Series I. were adopted as base angles. For reasons to be explained hereafter, I do not make use of Series II. for direct comparison of other stations with Toronto.

[1] Not 46° 45′·5, as formerly printed, Table XVI, 1846.

Needle *C* lost much magnetism between February 7 and May 8, 1843, but appears to have preserved it unchanged from that date to about September 7. The axles of this needle, however, contracted rust, and it was at no time as good as *A*. I was twice obliged to change them. Still the observations with needle *C* afford an independent series of determinations of force over a large part of the route, and are here brought forward to corroborate the others.

18. *Example of Reduction with Fox's Needle A.*

At the Isle d'Urval, Lachine, Station II, observed on April 30 the following angles of deflection :—

With 2·5 gr.	27° 27′·2	Temp. 47°·0	
3·0 gr.	33° 37′·0		
3·5 gr.	40° 30′·9		
4·0 gr.	47° 55′·0		
Then log. sin, base angle	= 27° 2′·3	= 9·657616	
log. sin, observed angle	= 27° 27′·2	= 9·663762	
Relative force, Isle d'Urval		= 9·993854	= 0·9859
Standard force at Toronto, 1·836		= 0·263872	
	Value by 2·5 gr.	0·257726	= 1·8108
In like manner by 3·0 gr.			1·8132
„ 3·5 gr.			1·7957
„ 4·0 gr.			1·8023
		0·256597	= 1·8055
	$1 - (t^\circ - t^\circ_1)\,q = 1{\cdot}00016$	0·000069	
On the Relative Scale		0·256666	= 1·8058
To convert this into Absolute Scale			
Multiply by the ratio $\frac{13{\cdot}896}{1{\cdot}836}$		= 0·879017	
On the Absolute Scale		1·135683	= 13·667

In this example the greatest difference of one of the partial values from the mean of the whole four, amounts to one *two-hundredth* part of the quantity.

19. *Relative Horizontal Force.*

The determination of the relative horizontal force by the method of horizontal vibrations, although employed by travellers like Hansteen, Erman, and Fuss in high northern latitudes in the Old World, and by Sabine himself with a dip of 88°, at Melville Island and at Spitzbergen,[1] having been superseded by the discovery of methods of determining the relative total force, was not included

[1] *Experiments to determine the Figure of the Earth*, 1825, p. 481.

in the programme of observations for my survey. But by the month of September, after four or five months' exposure, and from the effects of a journey already extending to 2,700 miles, both Fox's and Lloyd's needles began to show symptoms of deterioration. I decided, therefore, after leaving Cumberland House (*see* Station CLXXXVIII) to add this to the other observations. For this purpose I had three suitable magnets, Nos. 30, 31, and 17, provided for the transportable magnetometers. There was also an oak box provided expressly for the purpose of determining the ratio $\frac{m}{X}$, in observations of the absolute horizontal force, and I had a theodolite, by employment of which the arcs of vibration could be much reduced and great precision attained in observing the times. It will be seen in the diary that the results are in general very accordant. Subjoined are the details of observation at the first station.

TABLE VIII.

Observed Times of Vibration at Beaver Lake, August 26, 1843.
Station CLXXXVIII. Dip 80° 34 ·2.

3-inch Magnet No. 30. Th. 65°					3-inch Magnet No. 31. Th. 66°				
Vibr.	Watch time	Vibr	Watch time	Interval 200 vibr.	Vibr	Watch time	Vibr	Watch time	Interval 200 vibr.
	h. m. s.		h. m. s.	m. s.		h. m. s.		h. m. s.	m. s.
0	9 41 47	200	9 57 22·5	15 35·5	0	10 9 30·8	200	10 25 0·1	16 30·2
10	42 34	210	58 8·5	34·5	10	10 20	210	—	—
20	43 21	220	58 56·5	35·5	20	11 9 8	220	27 40·8	16 31·0
30	44 8	230	59 43·0	35·0	28	11 49·8	228	28 20 0	30·2
40	44 54·4	240	10 0 29·8	35·4	38	12 39·0	238	29 9·6	30·6
50	45 41	250	10 1 16	35·0	48	13 29·0	248	29 59·5	30·5
62	46 37·6	262	2 12	34·4	58	14 18·0	258	30 49·0	31·0
72	47 24	272	2 59	35·0	68	15 7·5	268	31 38·8	31·3
80	48 1·2	280	3 36·8	35·6	78	15 57·0	278	32 28 0	31·0
90	48 48·5	290	4 23·0	34·5	88	16 47·0	288	33 17·6	30·6
100	49 35·0	300	5 9·5	34·5	98	17 36·4	298	34 7·0	30·6
					108	18 26·0	308	34 56·8	30·8
Mean time of 200 vibrations				15 34·99	Mean time of 200 vibrations .				16 30·71
Whence of 1 vibration .				4·6749 *s.*	Whence of 1 vibration . .				4·9536 *s.*
Corrected time . . .				4·6671 *s.*	Corrected time . . .				4·9447 *s.*

The corrections applied are—(1) To standard temperature of 50°; (2) For the torsion of the suspension thread; (3) For arc: the arc on commencement was usually under 10°; (4) For the rate of the watch (*see* the next Section). In the above examples an interval of twelve vibrations was allowed to pass, by inadvertence, after the 50th of bar 30; and the eighth was observed after the 20th, with bar 31, instead of the tenth. These little irregularities have no effect whatever on the result.

The value of K—the moment of inertia of the suspended magnet and its stirrup—having been ascertained once for all,[1] and the value of m—the magnetic moment of the bar at the time of observation—being also known, the force can now be computed.

20. *Example.*—Bar 30. August 26, 1843. Th. 65°.

Observed mean time of one vibration $4^{s}\cdot6749$	log	0·669777
Correction for rate and arc		9·999941
		9·669718
		2
		9·339436
Correction for torsion and reduction to 50°		9·998665
T^2 corrected ∴ $T = 4^{s}\cdot6671$		1·338101
π^2 K bar 30		1·334089
$\frac{\pi^2 K}{T^2} = mX$		9·995988
m on August 26 = 0·4289		9·632356
∴ Horizontal force in absolute value = 2·3101		= 0·363632
Observed dip 80° 34′·2	secant	= 0·785573
∴ Total force in absolute value ϕ = 14·100		= 1·149205

The probable error of the observed mean time of one vibration is small, and so also the effect of such error on the resulting values of the horizontal or total force. In the present example it is as follows:—

	Probable error of t (s.)	Effect on X	Effect on ϕ
Bar 30	± 0·0046	± ·0046	± ·025
31	± 0·0032	± ·3030	± ·018

I subjoin the value of the *probable error* of t for successive observations of No. 30 in 1844, one magnet being taken for all.

[1] See *Magnetical Instructions*, &c., by Lieutenant C. J. B. Riddell, R.A. London, 1844.

TABLE IX.

Probable Errors of the observed mean time of one Vibration of a suspended 3-inch magnet, No. 30; arc at commencement about 10°, at the end of 300 vibrations about 5°.

Date	Station	No.	Observed time of 1 vibration	Therm.	Error ±	Effect of Error on X ±	Effect of Error on φ ±	Dip
1844			s.	°	s. 0·00			° ′
July 12	Fort Vermilion .	CCXLII.	4·9235	77	082	·0003	·002	80 48·0
„ 24	Dunvegan . .	CCLX.	4·4500	48	189	·0023	·012	78 46·2
Aug. 5	Lesser Slave Lake	CCLXIV.	4·4508	60	030	·0003	·003	78 39·0
„ 17	Edmonton . .	CCLXXX.	4·2947	47	051	·0007	·003	77 54·2
„ 20	On Saskatchewan	CCLXXXI.	4·3774	55	034	·0005	·002	78 5·2
„ 21	On Saskatchewan	CCLXXXIII.	4·4325	45	020	·0003	·001	78 33·5
„ 22	Fort Pitt . .	CCLXXXIV.	4·4174	53	033	·0005	·002	78 41·0
„ 23	On Saskatchewan	CCLXXXV.	4·3598	?	047	·0006	·003	78 28·0
„ 24	On Saskatchewan	CCLXXXVII.	4·3523	50	157	·0021	·010	78 16·6
„ 26	Carlton House .	CCLXXXIX.	4·4645	70	016	·0002	·001	78 30·7
„ 27	On Saskatchewan	CCXC.	4·5641	65	094	·0011	·006	79 11·2
„ 29	Cumberland .	CLXXXIII.	4·7838	61	093	·0004	·002	80 20·0

21. It would have been scarcely necessary to go into so much detail if these observations were now published for the first time, but the reader who will turn to Plate XVII, 'Phil. Trans.,' 1846, and compare it with Table XLVIII, *ibid.* p. 321, will observe that these results, although given in the table, are disregarded on the map, which, as regards the western extension of the lines of equal magnetic force of 1·85 and 1·80, is made solely dependent upon the three following assigned values:—

	Relative Force Needle A.	Equivalent Total Force
At Vermilion	1·811	13·71 instead of 14·06
At Dunvegan	1·809	13·69 „ 13·99
At Edmonton	1·809	13·69 „ 14·05

That these values are not likely to be correct is shown by their exceptional disagreement from the absolute determinations, a disagreement of which there is no other example in the whole series. They were obtained by comparing the angles of deflection of Fox's needle A at these stations in July and August, with the angles subsequently given at Toronto by the same weights in December,[1] and this comparison is vitiated by the fact that the axles of needle A were removed at Cumberland House on August 30, and a new pair

[1] See Tables XVI, XVII, *Phil. Trans.*, 1846, p. 297.

of axles applied to that needle. These gave no satisfaction, and were thought indeed to work worse than the old ones, which were in the end replaced, after an attempt to repolish them. This necessarily broke the series. Instead of referring the above observations to Toronto in December as a base, I refer them to the observations at Lake Athabasca on July 3 as a base, and find that they now agree with the absolute determinations nearly.

Referred to Lake Athabasca base, value 1·8348.

	Relative Force Needle A.	Equivalent Total Force ϕ	By Absolutes ϕ
At Vermilion	1·8642	14·109	14·061
At Dunvegan	1·8565	14·048	13·989
At Edmonton	1·8558	14·046	14·054

This correction is borne out by the observations in British Columbia, Washington territory, and Vancouver Island, by Captain R. W. Haig, R.A., in 1858–60. The lines of total force of 1·85 and 1·80 in relative terms, or 14·00 and 13·62 in absolute measure, should have been carried considerably further West and South than they were drawn by General Sabine in 1846. Captain Haig made the line of 13·60 (or 1·80) intersect the 50th parallel, in longitude 113° 35′, with which, allowing something for difference of epoch, the present revised values on the Saskatchewan and Peace River are in accord. Taking, as another test, the intersection of the meridian of 115° with the parallel of 45°, through which point the line of 1·70 was formerly drawn, Captain Haig's line of 13·23 = 1·75 passes through that point, as does the line laid down from the above observations, or very near it.[1]

Another feature of interest is disclosed by thus giving their due weight to the absolute determinations on the Saskatchewan. It is that a second local focus of maximum intensity occurs on that river in about latitude 53° longitude 108° W., corresponding to one on the Churchill or English River in latitude 55½° longitude 105° W.,[2] and that the direction of the lines of equal intensity must be considerably influenced by the great intrusive mass of the Rocky Mountains.

[1] The total force at Toronto in 1844 has been assumed throughout this work as 13·896; it was in 1860, 13·811, a decrease of 0·085 in 16½ years, or at the rate of 0·0051 per annum. Where Captain Haig found a total force of 13·60 in 1860, it was about 13·68 in 1844; and where his force of 13·23 is found, it was then 13·31 or 1·76 nearly. *Phil. Trans.*, 1864, p. 161, and Pl. III.

[2] *See* Stations CCV, CCVII, CXCVII, and Stations CCLXXXIV, CCLXXXV, and CCLXXXVII.

22. *Absolute Horizontal Force.*

My Report on the observations of absolute horizontal force (1845) was incorporated, in an abridged form, by Lieut-Colonel Sabine in his VIIth Contribution,[1] and it is not necessary to repeat all the details of observation which will be found there.

The following is a list of the stations, I add to each.

(1). The total force ϕ_1 deduced from the vibrations alone, for a comparison with the partial results treated under the preceding section, employing an interpolated value of m.

(2). The total force ϕ_2 deduced from the complete observation of vibration and deflection, employing the value of m actually observed.

(3). The total force ϕ_3 deduced from the observations of relative force with Fox's or Lloyd's needle, which value is in every respect independent of the other.

(4). The standard value of ϕ for the station, as deduced from all the observations, in the manner explained in the next section following.

TABLE X.

Comparison of Values of the Total Force as deduced from different and independent observations at the principal Stations.

No. of Station	Station	Total Force					Mean value adopted
		By vibrations alone ϕ_1	By vibration and deflection ϕ_2	W.	By static needles ϕ_3	W	ϕ
XXXIV.	Toronto . . .	13·900	13·904	0·45	—	—	13·896
XLIX.	Sault St. Marie .	13·790	13·824	0·38	—	—	13·824
LXIX.	Fort William[2] .	13·956	13·945	0·75	14·135	1·80	14·078
XC.	Fort Francis . .	14·032	14·047	0·75	14·009	1·05	14·023
C.	Rat Portage . .	13·971	13·964	0·30	14·053	0·60	14·023
CVIII.	Fort Alexander .	14·198	14·207	0·45	14·047	0·60	14·098
CXIII.	Fort Garry . .	14·070	14·006	0·30	14·072	2·30	14·070
CXXXVI.	Norway House .	14·155	14·166	0·75	14·129	3·4	14·136
CLXII.	York Factory . .	14·067	14·071	0·30	14·064	2·25	14·098
CLXX.	Cross Lake . .	14·242	14·199	0·60	14·203	0·85	14·201
CLXXXIII.	Cumberland House	14·151	14·184	0·45	14·142	3·30	13·782
CCLXXXIX.	Carlton House .	13·738	13·782	0·37	—	—	13·782
CCLXXX.	Edmonton . .	14·027	14·054	0·45	13·982	1·0	14·000
CCXI.	Lake à la Crosse .	14·002	13·983	0·60	14·028	2·30	13·990
CCXXIX.	Fort Chipewyan .	13·900	13·886	2·11	13·989	1·95	13·887
CCXLII.	Fort Vermilion .	14·072	14·061	0·45	14·004	1·0	14·022
CCLX.	Fort Dunvegan .	14·027	13·989	0·45	14·006	1·0	14·000
CCCVII.	Fort Resolution .	13·954	13·956	0·45	—	—	13·956
CCXCV.	Fort Simpson . .	13·846	13·808	1·50	—	—	13·808
CCXCIV.	Fort Norman . .	13·622	13·653	0·37	—	—	13·653
CCXCIII.	Fort Good Hope .	13·635	13·681	0·60	—	—	13·681

[1] *Phil. Trans.*, 1846, p. 287.

[2] If we take the result of 1843 only, at Fort William, to compare with the

23. The mean difference between the total force resulting from vibrations only, and the total force resulting from the complete observation of vibration and deflection, that is to say, *the square root of the mean of the squares* of 21 observed differences, is in value 0·030 nearly, (0·0298) representing about *one five-hundredth part* of the quantity itself. But the mean difference between the value deduced from the complete observation of horizontal force, and the independent values given by the relative observations, that is to say, by the use of Fox's and Lloyd's needles, is, as must be expected, somewhat larger; it amounts in value to 0·084, and is about $\frac{1}{162}$nd part of the quantity itself. If the latter instruments were always in perfect order, they would deserve almost entire confidence, and the results would derive little or no additional weight by combining the less perfect determination; but that was not the case, and probably never can be the case in practice, under the circumstances of a long land journey. The best value for each station of observation under such circumstances is to be obtained by giving proportionate weight to the different results, as described in the next section. I may observe also that the exclusion of the result at Fort William in 1844 would reduce the difference to $\frac{1}{200}$th part.

24. *Combining the Observations of Force.*

The magnetic force having been observed, in no less than four different ways, of unequal value, and the number of observations taken at different stations having also varied considerably, it is necessary to determine some consistent way of *weighting* the results, (1) so as to obtain the most probable mean value for each station, and (2) to assign to this station value its proper weight when combined with others. The general principles applicable to both cases were investigated by the late Professor Humphrey Lloyd in the Report on the Magnetic Survey of Great Britain in 1836.[1] He shows that if x_1, x_2, x_3, x_n, be n values of the quantity x obtained by separate and independent observations, also if a be their arithmetical mean, 'then the *probable error* of this mean, *i.e.* the limit on either side of which there are *equal chances* of the actual error lying,' is given by the formula

static needles, which were all observed in that year, viz. 13·998, the difference is materially less. The force in 1844 was only 13·908; *see* Station LXIX.

[1] *Eighth Report of the British Association*, 1838, p. 95; *see* also *Airy on the Algebraical and Numerical Theory of Errors of Observation*, p. 47.

$$E^2 = \frac{0{\cdot}4549\ \Sigma\ (x-a)^2}{n\ (n-1)}$$

in which $\Sigma\ (x-a)^2$ denotes the sum of the squares of the differences of the several partial results and the mean. Also the probable error of any single result ε as deduced from comparison with the rest, is given by the formula $\varepsilon = \sqrt{n}\,E^2$.

The *weight* of the single result, and the *weight* of the mean, are as the inverse squares of the probable errors.

25. There are only two stations in the entire list besides Toronto at which my stay was sufficiently long to have admitted of a multiplication of observations with a view to determining probable errors. These were Lake Athabasca and Fort Simpson.[1] I regret not having taken more advantage of them, but the great fatigue of continuous observation through the 24^h with only one assistant, often prolonged for many hours at a stretch, at intervals of only 1^m, may be pleaded in excuse for the omission.[2] The consequence is that I cannot appeal to my own observations for the *probable error* of an observation of dip in such high latitudes; and as the dip enters into the deduction of total force from observations with Lloyd's statical needles, and also with the transportable magnetometers, it is a very important factor in their weight: but allowing the instrument and the observations to be on an equality, I find two series of dips which throw some light on the question: these are Dr. J. Rae's observations at York Factory in 1845–6, and the same traveller's observations in conjunction with Sir John Richardson, at Fort Confidence, Great Bear Lake, in 1848–9.

At York Factory we have the following:—

1845–6	Mean Dip	E	ε
	° ′	′	′
November	83 43·1	0·83	2·36
December	83 45·1	1·15	3·27
January	83 45·1	0·40	1·14
February	83 42·1	0·95	2·83
March	83 42·5	0·72	2·05
April–May . . .	83 39·3	0·58	1·92

There are nine observations in February, eleven between April 1 and May 16, eight in each of the other months. We may then consider the probable error of a single observation for dip at York Factory ± 2′·26.

[1] Nos. CCXXIX and CCXCV.

[2] Besides the monthly term days, on Oct. 26, for 6*h.*; Decem. 1, 8*h.*; Jan. 4, 10*h.*; Jan. 5, 10*h.*; April 16, 14*h.*, and for many shorter periods on other occasions.

The observations at Fort Confidence were taken without reversing the poles. That is to say, on one day of observation the poles were direct, and on the next succeeding day they were reversed. I have coupled as many consecutive observations of the same needle as occur, which give eight complete dips in two of the months, and find:

1848	Mean Dip	E	ε
	° ′	′	′
October	84 49·7	0·39	1·12
November . . .	84 51·2	0·65	1·84

We may therefore take ± 1′·48 as the probable error of a single observation for dip at Fort Confidence. I have already shown (p. 16), by the agreement of results by two needles, that it must have been very small at my stations.

Turning to the observations at Toronto, and taking only those in which the poles were reversed, I find as follows:

1844	Mean	E	ε
	° ′	′	′
January	75 15·4	0·41	1·25
February	75 15·7	0·46	1·30
March	75 14·5	0·71	1·95
April	75 13·2	0·42	1·20
May	75 12·3	0·64	1·82
June	75 11·6	0·34	1·03
July	75 10·1	0·66	1·97
August	75 10·1	0·48	1·28
September . . .	75 17·9	0·68	1·92
October	75 17·9	0·71	2·13
November . . .	75 20·3	1·10	3·11
December . . .	75 19·0	1·41	3·71
Mean			1·89

Whence we may conclude that the probable error of a single observation of dip at Toronto was under 2′·0.

In deducing the relative total force from an observation with Lloyd's static needles, an error of ± 2′ in the dip employed is generally quite inappreciable. In the most unfavourable case it amounts to little over unity in the fourth decimal.

In deducing the total force in absolute measure from a determination of the horizontal force, the effect of an error in the dip of ± 2′·0 on the resulting force is much more considerable.

It is at Fort Confidence in absolute measure ± 0·063
Fort Simpson . . . . . ± 0·056
York Factory . . . . . ± 0·071
Toronto . . . . . . ± 0·032

This great disproportion results necessarily from the formulæ employed. For

If ϕ = total force,

X = horizontal force,

δ = the dip,

θ = the angle of deflection produced by a constant weight,

then with Lloyd's needles $\phi = \frac{\cos\theta}{\sin(\delta-\theta)}$, whereas by horizontal force ϕ = X secant δ; now $(\delta - \theta)$ is usually so adjusted as not to differ much from 90°, in which case the sines vary very slowly, and in the widest deviation from 90° which occurs in the whole series, namely, at York Factory, the effect of an error of $\pm 10'$ of dip on the numerical value of ϕ is only 0·035, whereas, the secants increasing very rapidly, the same error increases the value of X *secant* δ more than ten times as much, or 0·385.

Such being the case, the general agreement of results deduced by such dissimilar means is a proof that the errors of observation are small.

26. The horizontal force given, is itself of unequal weight, as the observations come under two divisions:

(*a*) Where the result rests on vibrations only, the value of m, the magnetic moment of the magnet, not having been determined by deflection at the same station (*see* § 19).

(*b*) Where it was so determined (§ 20).

In the former case the values of m have been interpolated from the observations preceding and following, and their error, if any, is very small.

The *probable error* of the mean time of one vibration has been shown (§ 20) to be almost insignificant.

Reviewing these various conditions, I have adopted the following scale of *weights* for the numerical results of total force:—

(1). From horizontal vibration only, for each magnet, 1·0.

(2). From the same, combined with deflections, for each magnet, 1·5.

(3). By Lloyd's static needle when the angles were unfavourable, 2·0.

(4). The same if the angles were favourable, 2·5.

(5). By Fox's needle A, with which the dip is eliminated:

employing four constant weights, and when the needle was in good condition, 6·0.

(6). By Fox's needles B and C when employed, these results not having the same direct connection with the base station, 4·0.

The values have been assigned to the stations by thus weighting the partial results, and the stations weighted among themselves by the aggregate of the numbers, divided for convenience by 10. The result is to give a marked preponderance to the values of the force obtained by the use of Fox's instrument, but not greater than its superiority as a means of measurement appears to justify.

27. *Attempted Measurements of the Relative Total Force by means of the Induction Inclinometer.*

'When a bar of soft iron is held in any direction not perpendicular to that of the earth's magnetic force, it becomes a temporary magnet, by the inducing action of that part of the force which acts in its direction. The changes of the induced magnetism may be assumed to be proportional to the inducing force; and as the former may be measured by their effects, the latter become known.' [1] This principle was first applied by the late Provost Lloyd in 1842, by the invention of his induction inclinometer,[2] now well known, and I was provided with the first instrument of that construction which was sent out of England. I believe also that the results of my use of it at Lake Athabasca and Fort Simpson in 1843–4 were the first published; on this account I shall be pardoned for quoting at length the judgment which that amiable and gifted philosopher passed upon those results.

Professor Humphrey Lloyd to Lieut.-Colonel Lefroy.

April 30, 1857.

I have read very carefully your account [3] of the induction inclinometer and its results; and am much pleased with your conclusions, which are skilfully and *legitimately* drawn (*sic*). I find one slight error in the deduction of the co-efficient by the deflection method, which (I believe) was my

[1] See *Observations made at the Magnetical and Meteorological Observatory at Trinity College, Dublin, under direction of the Rev. Humphrey Lloyd, D.D.*, vol. i. p. 64. Longmans, 1865.

[2] See *Proceedings of the Royal Irish Academy*, vol. ii. p. 210.

[3] *Athabasca Observations*, 1855, p. 41.

own, and arose from the neglect of a small quantity in the approximation, which was of the same order of magnitude as those retained; it occurs on p. 44, where the quantity within the brackets should be 3 cos $^2 \phi - 1$ instead of cos $^2 \phi + 1$. But as cos ϕ is nearly equal to unity, the values of both are nearly the same or equal to 2. There are some misprints which I have marked with pencil.

I am very well satisfied with your result. At the same time I suppose the most complete verification of the instrument would be a comparison of the *vertical force* obtained from it with that deduced from the V. F. magnetometer. I return your volume with thanks, and send along with it a little paper of mine, which gives the more correct deduction of the coefficient.

(*Signed*) H. LLOYD.

The question referred to in these remarks does not affect the present discussion. It occurred to me on Mackenzie's River that if the variations in the angle of deflection of the suspended magnet in a permanent instrument, under the fluctuating force of induced magnetism in the iron bar, were a measure of horary changes of the vertical component of the force, those angles themselves, if recorded in different places, must, in some way, measure the relative amount of that component which, when the dip is 65° or beyond it, is more than *nine-tenths* of the whole force, and at 82° is *ninety-nine hundredths* of it. Acting on this belief, I made it a practice in 1844, when time permitted, to ascertain the mean value of the angle of deflection produced on a suspended magnet by the induced magnetism locally present in a soft iron bar of 12·2 inches in length and 0·75 inch in diameter, supported in a vertical position at 5·03 inches distance from it.

The suspended magnet was 2·5 inches long. The deflecting bar was firmly fixed in a brass collar at one end, and passed through a brass socket in the frame of the instrument, in such a way tha when standing above the frame, the lower end, or North Pole, acted on the suspended magnet, and when hanging by the collar, below the frame, the upper end, or South Pole, acted on it. The centre of the collar, and consequently that part of the temporary magnet corresponding with it, was in the same plane on each reversal. The effective pole of the bar was also at an equal distance from the axis of the magnet, above it or below it, in both cases.

The soft iron bar possessed a small amount of permanent magnetism, which tended to augment the angle of deflection of the suspended magnet in one position and to diminish it in the other. The induced magnetism is also influenced by the temperature, but the effect being comparatively small, I have not thought it necessary in a tentative comparison to apply any correction for it. ± 10° Fahr. correspond to ∓3′·9 in the angles.

In the subjoined table

Let u = The angle of the deflection when the permanent and the induced magnetism were of the same sign.

u' = The angle of deflection when they were of the contrary signs.

$\frac{1}{2}$ D = Half the difference between these two angles, being a measure of the permanent magnetism in the iron bar.

θ = The inclination at the station.

t = The time of one vibration of the suspended magnet. This not having been observed, I have substituted the time of one vibration of magnet No. 30, corrected for loss of magnetic moment between the date of observation and October 11.

TABLE XI.

Angles of Deflection by Induced Magnetism. The Stations arranged in order of Dip.

1844	Station	Deflection			½ D	t	θ	p
		u	u'	Th.		No. 30		
		° ′	° ′	°	° ′	s	° ′	
Nov. 4	Sault St. Marie .	28 46·3	26 46·5	45	1 0·	4·2292	77 19·5	·1212
Sept. 29	Fort Francis .	27 47·5	27 45·4	60	0 1·	4·2395	77 30·0	·1241
Aug. 17	Edmonton Ho. .	29 40·5	27 24·9	56	1 8·	4·3122	77 54·3	·1166
Oct. 11	Fort William .	30 55·2	29 10·8	73	0 51·	4·3471	77 59·5	·1231
Aug. 26	Carlton . .	31 36·3	30 31·0	70	0 33·	4·4576	78 31·7	·1374
Oct. 21	White River (1)	31 50·6	29 0·5		1 55·	4·4082	78 31·0	·1241
Oct. 23	„ (2)	32 47·2	30 5·7	55	1 21·	—	78 32·0	·1190
July 24	Dunvegan .	32 44·8	30 38·1	70	1 3·	4·4906	78 46·2	·1226
Sept. 19	Fort Alexander	32 19·1	31 46·7	55	0 16·	4·4898	79 3·0	·1211
July 11	Fort Vermilion	41 22·8	38 32·2	32	1 25·	4·9483	80 48·0	·1355
Sept. 7	Norway House .	43 10·3	40 53·9	55	1 8·	5·0121	81 11·2	·1399
July 1	Fort Chipewyan	46 51·0	43 46·4	50	1 33·	5·1845	81 36·8	·1493
Oct. 14	„ .	52 21·7	41 35·9		5 23·	—	81 37·6	·1626
Oct. 31	„ .	52 23·7	41 36·6	39	5 28·	—	„	·1609
Mar. 30	Fort Simpson .	50 57·4	47 55·8		1 31·	—	81 52·2	·1665
May 2	„ .	48 20·2	45 57·4	37	1 11·	—	„	·1541
May 25	„ .	51 58·9	42 52·8	60	4 33·	—	„	·1505
June 12	„ .	49 50·8	44 14·5	56	2 48·	5·3075	„	·1536
June 20	Slave L. (Big Is.)	54 55·0	46 7·3	75	4 24·	—	82 8·7	·1699
May 28	Fort Norman .	59 28·5	52 5·7	43	3 41	—	82 34·3	·1943
June 2	„ .	62 45·4	49 55·9	36	6 30·	5·6[illegible]17	„	·2041
June 22	Fort Resolution	57 12·8	52 25·4	50	2 24·	5·5823	82 44·4	·1822
May 29	Fort Good Hope	61 21·8	55 48·0	44	2 47·	6·4973	82 59·9	·2023

By the theory of the induction inclinometer

$$tan\ u + tan\ u' = 2\ k\ r\ tan\ \theta,$$

where k = an unknown co-efficient of the vertical force Y, such that the intensity of the induced magnetism is equal to k Y.
also r = a constant depending upon the distance :[1] and let $p = k\,r$.

It appears evident by the sequence of values of p, which have been calculated in the last column of the preceding table, that this co-efficient is *not a constant*, but varies with the dip. On taking the means we have :

TABLE XII.

Dip Between	Observations	Mean θ	Tan θ	p	$p \frac{\tan\theta}{\tan\theta_1}$
77°—78°	4	77° 40′·8	4·5800	0·1194	0·1194
78—79	3	78 31·9	4·9298	0·1268	0·1285
79—80	1	79 3·0	5·1686	0·1211	0·1348
80—81	1	80 48·0	6·1742	0·1355	0·1610
81—82	5	81 43·9	6·8813	0·1575	0·1787
82—83	5	82 36·3	7·7048	0·1905	0·2009

The irregularity in the values of ½ D in Table XI, to whatever cause attributable, are enough to obscure any regular law that may obtain as to increase in the value of p ; but if we take, as above, the mean dip of the first group of four stations ($\theta = 77° 40'·8$) and the corresponding mean value of p (= 0·1194) for a basis of comparison, the last two columns show that p increases very nearly, but apparently not quite, in the ratio of the tangent of the dip.

The observations require to be repeated with greater attention to every precaution, but they appear to prove—

(1). That no degree of accuracy in the determination of p at a base station will enable θ to be deduced from the angles u and u' at any other station, by the given formula

$$2\,p\ tan\ \theta = tan\ u + tan\ u',$$

we require for that purpose a new value of p, which involves in fact a knowledge of θ itself. Lloyd himself could only obtain results of *absolute inclination* which were approximations to the truth.[2]

[1] *See* a note on the theory of the instrument in the Appendix.

[2] *Proceedings Royal Irish Academy*, 1842, and *Papers on Physical Science*, 1877, p. 225.

(2). That for the same reason we cannot infer the relative values of Y at two stations, as might be done if p were constant.[1]

My observations appear to be not entirely trouble thrown away if they establish these conclusions experimentally.

28. *Results.*

The curvature of all the magnetic lines in the part of the world we are considering is such that the method of grouping first employed with such great success by Lloyd in discussing the magnetic survey of Ireland in 1835 is not applicable. As General Sabine remarked, 'They are not straight lines on any projection; they are not parallel; nor are they equidistant.'[2] He made the attempt to combine them by the method of *least squares*, and his calculations, which fill many sheets, may be referred to at Kew, but he was ultimately obliged to revert to a graphical method of projection. I have also endeavoured, by taking much smaller districts, to deduce mean values for central points of a higher authority than individual results, but with the same experience: 'when the districts are taken sufficiently small to satisfy the required conditions of straightness, parallelism, and equidistance, irregularities of observation arising from station error and other causes became significant and materially affect the result.'

For the purpose of localising the focus of greatest intensity, and of determining its amount, a different course was adopted. It

[1] Since $Y = X \tan \theta$ we may substitute for $\tan \theta$ its equivalent $\frac{Y}{X}$

consequently $2p\frac{Y}{X} = \tan u + \tan u'$ (1)

whence if p were constant we should have

$$\frac{Y X_1}{X Y_1} = \frac{\tan u + \tan u}{\tan u_1 + \tan u'_1} \qquad (2)$$

$$\text{but } \frac{X_1}{X} = \frac{t^2}{t_1^2}$$

let then Y at the base station be accurately determined, and for Y write A,

$$\text{Then } Y_1 = A\,\frac{t_1^2}{t^2}\left(\frac{\tan u_1 + \tan u'_1}{\tan u + \tan u'}\right)$$

where all the quantities on the right-hand side may be accurately determined. p, however, not being constant, there is another factor, $\frac{p_1}{p}$ which cannot, as it seems, be determined, without accurately knowing θ, and if we know θ, we do not require the formula.

[2] *Phil. Trans.* 1846, p. 257.

being conceded that the isodynamic curves consist of a series of ovals or ellipses surrounding the point of greatest intensity, the late eminent mathematician, Mr. Archibald Smith, investigated the problem, and furnished General Sabine with the form of the equations, by which the co-ordinates of the common centre of all the ellipses, which is also the place of greatest intensity, could be determined from the observations; also its maximum value, the value of the semi-axes of the central ellipse, and their angle with the parallels of latitude be computed, all of which very laborious calculations were carried out under General Sabine's superintendence with the following results:—

a. The geographical position of the point of maximum force was found to be in latitude 52° 19′ N., longitude 91° 59′ W.

b. The force at this point is 1·878, or in absolute measure 14·214.[1] This was exceeded at three stations under local influences, and over a very limited area, but it appears to be higher than exists anywhere else over a large area.

c. The value of the semi-axes of the ellipse of 1·875, or 14·191 in absolute measure, was found to be 223 and 85 geographical miles respectively.

d. The angle which the major axis makes with the parallel of latitude was found to be 66° 55′.

The position corresponds geographically to a small lake called Cat Fish Lake, about 200 miles beyond and to the N.W. of the height of land above Lake Nipigon, and is apparently easily accessible.

It seems likely that if the calculation were repeated with the slightly different numerical values I have now assigned to the force in many places, and especially with a due regard to the westerly extension of a comparative high force which I have shown to prevail on the Saskatchewan and north of it (Stations CCLX to CCLXXXVII), these elements would undergo some modification: but they rest upon eighty-two equations of condition of the form,

$$\text{Force} = z = a x^2 + b x y + c y^2 + d x + e y + f$$

and as the resulting final equations run into very large figures, there is good reason to suppose that the substantial result would remain unaffected.

This result confirmed in a remarkable manner the conclusion

[1] So given also by Sabine, p. 251, but erroneously marked on his map 14·88.

to which the illustrious Gauss had been led by his 'General Theory of Terrestrial Magnetism' in 1838.[1] On transferring his closed oval of greatest intensity to the map, it is found that the above ellipse occupies nearly the centre of it, in longitude, but is situated in the southern half of it.

The oval represents a force of 1750·0, and the maximum towards the centre is 1763·7. These values expressed in British units are 13·245 and 13·349 respectively, being materially lower than the values actually found.

The isoclinal line of 80°, which by the theory cuts the meridian of 95° W. in latitude 52°, was found almost exactly in that place.

On the other hand, the variations were considerably out, the lines of equal variation falling to the east of their theoretical places by 4° or 5° of longitude; that even so near an approach to the truth, however, should have been made in the then state of observation is sufficiently surprising.

The polarity of the earth, considered as a magnet, appears to be less definitely localised than has been supposed. Probably, from geological causes, the forces producing a maximum of intensity are divided towards the focus, and we have three foci at least, separated by decidedly lower values:

A in or about lat.	52°	long.	92°	W.
B "	"	56	"	106	W.
C "	"	53	"	107	W.

but a much more detailed survey is required to map down the intensity hereabouts with precision.

29. The isoclinal lines laid down on the maps annexed to this volume are drawn as they were actually found, for the purpose of calling attention to an apparent relation between their deviation from regular curves, and the course of the adjacent rivers—a circumstance, so far as I am aware, not before observed. This has been done by taking the mean distance between the lines from Sabine's map, and laying down two points from each station for the two adjacent isoclinals. These points being first connected by straight lines, the curves have been drawn by eye to divide the irregularities, and to conform as nearly as can be judged to the observations.[2]

[1] *Scientific Memoirs*, vol. ii. 1838.
[2] See the Rev. S. J. Perry's 'Magnetic Survey of Belgium,' *Phil. Trans.*, 1873.

30. *Secular Changes.*

Toronto is as yet the only spot in British America for which the rate of secular change since 1843 has been ascertained.

At that station

(*a*). The westerly declination increased between 1843 and 1871 from 1° 24′ to 2° 48′ W., at a mean rate of + 1′·952 per annum.

(*b*). The dip increased in the same period from 75° 15′·5 in 1843 to 75° 25′·0 in 1859, after which it declined, and was again 75° 16′·8 in 1871.

(*c*). The total force increased from 1845 to 1849, but has since decreased, following the change in the dip. In 1845, 13·942; in 1849, 13·952; in 1871, 13·776.[1]

In quoting the variation observations of Lieutenant Blakiston, R.A., in 1857, and those of Captain Haig, R.A., in British Columbia in 1860–1, they are reduced to the epoch 1844·0 by applying the same rate of change as was adopted by General Sabine, who took for epoch 1842·5 as best suited to the great body of observations treated by him.[2]

There is an irreconcilable difference between Franklin's dips observed in 1819–20, and those observed in 1825–6. The former are much too great. Thus at Fort Chipewyan:

	° ′
July 14, 1820	85 23·6
July 24, 1825	81 26·1

It is necessary, therefore, to disregard the observations of the first voyage.[3] The second voyage furnishes data for comparison at nine stations.

	1825	° ′	1843–4	° ′
Penetanguishene .	April 18	76 16·0	November 14, 1844 .	76 20·1
Fort William .	May 11	78 20·0	May 29, 1843 . .	78 10·0
Savannah Port (S.W. end F., N.E. end L.) .	May 20	98 39·1	June 6, 1843 . .	78 21·8
Fort Frances .	May 27	77 18·1	June 14, 1843 . .	77 27·5
Fort Alexander .	June 6	78 47·1	1843–4 . . .	78 58·4
Cumberland Ho .	June 28	80 21·1	1843–4 . . .	80 25·0
Isle à la Crosse .	July 11	79 55·0	September 9, 1843 .	80 9·8
Fort Chipewyan .	July 24	81 26·1	1843–4 . . .	81 36·8
Fort Simpson .	Aug. 5	81 53·1	March to May, 1844 .	81 52·2

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[1] These are the revised values of 1857, in which slight corrections were applied to the moments of inertia of the rings; *see* 'Toronto,' vol. iii., p. cvi.

[2] *Phil. Trans.*, 1872, p. 355.

[3] *See* Appendix to *Franklin's Second Expedition*, p. cxxxv.

The comparison points to a small increase of dip over the whole region, except at Fort William and the next station, where Franklin's dips are not consistent with any regular movement of the isoclinal lines.

Stations for comparison of variation are rather more numerous, but the uncertainty of this observation makes the conclusions individually less decisive. I do not include any of those of Franklin in which the variation was estimated from the sun's bearings at noon.

It appears that about the region of the great lakes, easterly variations were decreasing, or the line of no variation moving westward, between 1820 and 1844; while, on the contrary, in more northern regions and to the westward they were increasing; the great loops of equal variation which connect the magnetic pole in latitude 70° N. with the pole of the earth, being under a process of expansion, of which the effect was to crowd nearer together the lines of variation of less than 15° E. in central parts of the continent. (*See* p. 111, York Factory.)

TABLE XIII.

Comparison of Declinations.

	1819–26	Var. East	1843–4	Var. East
		° ′		° ′
Sault St. Marie . .	May 2	2 32·8	Nov. 4, 1844	1 1·1
Fort William . .	May 12	7 17·5	1843–4	5 47·8
Chien Portage, N.E. .	May 18	11 2·8	June 3, 1843 June 4, 1843	5 40·8 *a* 6 51·1 *a*
Savannah River . .	May 21	9 23·9	June 6, 1843	8 6·3 *b*
Fort Francis . . .	May 28	10 42·5	1843–4	9 35·0
Fort Alexander . .	June 5	15 15·7	1843–4	14 0·4
Lake Winnipeg nearly opposite the Dog's Head	June 2	14 46·0	July 7, 1843	21 38·3 *c*
York Factory . .	Sept. 1819	6 0·3	July 24–6	9 0·6
Long Portage, Jack R. .	Sept. 24, 1819	11 10·4	July 19	12 36·4
Norway House Gates .	Oct. 7, 1819	14 26·1	1843–4	15 35·0
Cumberland House .	Nov. 19	17 17·5	—	—
" " . .	May 22, 1825	19 14·3	1843–4	19 32·4
Carlton House . .	Jan. 31, 1820	20 44·8	Aug. 25, 1844	22 55·0
Isle à la Crosse . .	Feb. 1819	22 15·8	—	—
" " . .	June 27, 1825	23 19·3	Sept. 9, 1843	24 54·7
Fort Chipewyan . .	March 1820	22 49·6	—	—
" " . .	July 11, 1825	25 29·	1843–4	28 45·8
Fort Resolution . .	July 30, 1825	29 15·6	June 22, 1844	37 12·5 E.
The Ramparts on Mackenzie's River *d* .	Aug. 7, 1825	44 5·0	May 30, 1844	42 26·0

a Franklin's Station is between these two.
b This was 10 miles E. of Franklin's Station.
c Local disturbance.
d About seven miles to the W. of the position of Fort Good Hope in 1844, Franklin's Fort Good Hope being 100 miles nearer the mouth of the river. The corresponding observation entered is an imperfect one made at the Fort Good Hope of my visit.

31. *Stations in Canada and the United States.*

Before proceeding to the connected series of observations in the North-West which form the body of the magnetic survey, it will be convenient to reproduce, in order of date, a number of observations made at different times in Canada and the United States; principally in the course of a tour I made in the latter in 1842, before proceeding to Toronto, by Lieut.-Colonel Sabine's desire, to communicate with the eminent American observers, Bache, Renwick, Loomis, Nicollet, whose observations are embodied in his paper of 1846. The most extensive contributor, Dr. Locke, of Cincinnati, I was not so fortunate as to meet, nor Major James D. Graham, of the U.S. Corps of Topographical Engineers, to whom we owe the determination of the dip at thirty-eight stations, taken in connection with the North-East Boundary Commission, 1841–5.

The absolute horizontal force was determined at six of the following stations with a German transportable magnetometer by Meyerstein of Göttingen, on the plan of Professor Wilhelm Weber. Fox's circle was used at twenty-four stations, and Gambey's circle with Lloyd's needles at fifteen stations. At ten of these a new pair of needles called L3 and L4 was employed. They were made in 1845 and gave remarkably good results.

The details of the absolute determinations have been fully published ('Phil. Trans.' 1846). I subjoin the results, converted into total force (ϕ_1), together with the value of the latter by the independent measurements in Table XIV (ϕ) for comparison.

1842	Station	X	δ	ϕ_1	ϕ
Sept. 7	Quebec	3·040	77° 15′·3	13·780	13·844
Sept. 16	St. Helen's	3·064	77 10·0	13·795	13·751
Sept. 25	New Yo k	4·008	72 35·6	13·398	13·426
Oct. 1	Cambridge	3·665	74 16·1	13·519	13·458
Oct. 13	Philadelphia	4·176	71 59·0	13·502	13·577
Nov. 12	Chicago	4·105	72 39·3	13·771	13·820
Oct. 28	TORONTO	3·515	75 15·6	13·830	
Dec. 19	,,	3·550	75 15·7	13·979	13·896
March 1843	,,	3·541	75 14·5	13·868	

The observer at ten stations marked Y in the following list was Lieutenant, now Lieut-General C. Younghusband, C.B. Some of the observations have not before been published.

TABLE XIV.

Observations in Canada and the United States. Stations 1 *to* 18 *were referred by Sabine to Woolwich as a Base, with value* 1·372. *I have for consistency referred them all to Toronto, value* 1·836 ; *the results are almost identical.*

More exact identification of the localities will be found in the Appendix.

No.				Latitude	Longitude	Dip	Relative intensity	Absolute intensity	Observer
1	1842	Sept. 1	Quebec, *a*	46° 49′·5	71° 14′·2	F.A. 77° 15′·3	F.A. 1·8291	13·844	
—	1845	June 23	Quebec, *b*	46 48·6	71 13·3	G. 1 77 8·8	L. 1 1·8013	13·633	Y.
—	”	”	”	—	—	—	L. 2 1·8006	13·628	
2	1842	Sept. 6	Three Rivers	46 21·0	72 32·0	F.A. 77 10·7	F.A. 1·8290	13·843	
3	”	Sept. 8	Sorel	46 2·0	73 3·0	F.A. 77 16·4	F.A. 1·8169	13·751	
—	”	”	”	—	—	F.C. 77 16·5 [1]	—	—	
4	”	Sept. 10	Kingsey	45 46·0	72 12·0	F.A. 77 40·0	F.A. 1·8080	13·687	
5	”	Sept. 12	Stanstead	45 2·0	72 7·0	F.A. 77 19·2	F.A. 1·8000	13·624	
6	”	Sept. 14	St. John's, L.C.	45 17·0	73 15·0	F.A. 77 0·1	—	—	
7	”	Sept. 16	St. Helen's Isle, Montreal	45 31·0	73 32·0	F.A. 77 13·1	F.A. 1·8128	13·720	
—	1843	April 25	”	—	—	G. 1 77 15·7 [2]	F.A. 1·8231	13·799	
—	”	April 29	”	—	—	G. 1 77 2·1	L. 1 1·8215	13·786	
—	”	April 29	”	—	—	G. 2 77 8·6	L. 2 1·8198	13·701	
—	1845	June 20	Montreal, The Mountain	45 31·0	73 33 3	G. 1 77 6·7	L. 1 1·7902	13·550	Y.
—	”	”	”	—	—	G. 2 77 10·3	L. 2 1·7865	13·521	Y.
8	1842	Sept. 26	Manhattanville, N.Y.	40 49·0	74 3·0	F.A. 72 39·5	F.A. 1·7700	13·396	
—	”	”	”	—	—	F.B. 72 31·8 [3]	F.B. 1·7782	13·456	
9	”	Sept. 28	Providence, R.I.	41 50·0	71 25·0	F.A. 74 0·0	F.A. 1·7811	13·477	
10	”	Oct. 1	Dorchester, Mass.	42 19·0	71 5·0	F.A. 74 12·8	F.A. 1·7608 [4]	13·327	
11	”	Oct. 3	Cambridge, Mass.	42 22·0	71 8·0	F.A. 74 19·5	F.A. 1·7782	13·458	
12	”	Oct. 6	Philadelphia	39 58·0	75 10·0	F.A. 71 59·0	F.A. 1·7938	13·577	L.
13	”	Oct. 8	Baltimore, *a*	39 17·0	76 37·5	F.A. 71 41·5 [5]	F.A. 1·7836	13·499	L.
—	”	”	” *b*	—	—	F.A. 71 47·8	—	—	L.
—	”	”	” *c*	39 15·0	76 38·0	F.A. 71 40·7	—	—	L.
14	”	Oct. 10	Washington, D.C.	38 53·0	77 1·0	F.A. 71 13·8	F.A. 1·7723	13·414	L.
15	”	Oct. 14	Princeton, N.J.	40 22·0	74 40·0	F.A. 72 43·5	F.A. 1·7842	13·504	L.

16	1842	Oct. 18	Newhaven, Conn. . . .	41 18·0	72 58·0	F.A. 73 27·4	F.A. 1·7775	13·453	L.
17	,,	Oct. 19	West Point, N.Y. . . .	41 24·0	74 1·0	F.A. 73 30·4	F.A. 1·8104	13·703	L.
—	,,	Oct. 20	,,	—	—	G. 1 73 32·7[6]	—	—	
18	,,	Oct. 21	Albany, N.Y. . . .	42 39·0	73 45·0	F.A. 74 44·6	F.A. 1·7982	13·610	L.
A	,,	Oct. 26	Toronto	43 39·0	79 21·0	F.A. 75 16·3	1·8360	13·896	
						R. 75 17·6			
19	,,	Nov. 3	Cleveland, Ohio . . .	41 30·0	81 42·0	F.A. 73 3·8	F.A. 1·8057	13·666	Y.
20	,,	Nov. 4	Detroit, Mich. . . .	42 25·0	83 0·0	F.A. 73 28·7	F.A. 1·8259	13·820	Y.
—	1845	Oct. 23	,,	—	—	G. 1 73 40·6	L. 3 1·8073	13·679	L.
—	,,	,,	,,	—	—	G. 2 73 37·0	L. 4 1·8111	13·707	L.
21	1842	Nov. 7	S. Manitou Isl. L. Mich. .	45 5·0	85 38·0	F.A. 75 56·6	F.A. 1·8552	14·041	Y.
22	,,	Nov. 11	Kingston, C.W., *a* . .	44 13·0	76 28·6	G. 1 77 18·8	L. 1 1·9533	14·782	L.
—	,,	,,	,, *a* . .	—	—	G. 2 77 19·1	L. 2 1·9781	15·160	L.
—	1843	April 18	,, *a* . .	—	—	G. 1 77 18·1	L. 1 1·9966	15·010	L.
—	,,	,,	,, *a* . .	—	—	—	L. 2 1·9964	15·111	L.
—	1845	June 10	,, *a* . .	—	—	G. 1 77 14·2	L. 1 1·9959	15·106	Y.
—	,,	,,	,, *a* . .	—	—	G. 2 77 14·7	L. 2 1·9971	15·115	Y.
—	,,	June 11	Kingston, Stewart's Point, *b*.	44 12·0	76 29·0	—	L. 1 1·9164	14·471	Y.
—	,,	,,	,,	—	—	—	L. 2 1·9062	14·427	Y.
—	,,	,,	Kingston, The Common, *c* .	44 13·0	76 30·0	—	L. 1 2·0498	15·478	Y.
—	,,	,,	,,	—	—	—	L. 2 2·0418	15·453	Y.
23	1842	Nov. 15	Chicago, Ill.	41 53·0	87 44·0	—	F.A. 1·8204	13·778	Y.
—	,,	Nov. 16	,,	—	—	F.A. 72 39·3	—	—	Y.
24	,,	Dec. 29	Hamilton, C.W. . . .	43 16·0	79 50·0	G. 1 74 56·7	L. 1 1·8262	13·824	J.
—	1845	Oct. 31	,,	—	—	G. 2 74 54·1	—	—	L.
A	1842	Dec. 30	Toronto, *see* p. 56 . .	43 39·0	79 21·0	—	—	—	
25	1843	Jan. 24	Barrie	44 21·0	79 41·0	F. 1 75 49·9	—	—	L.
26	,,	Jan. 26	Penetanguishene, *a* . .	44 47·0	79 58·0	F. 1 76 4·2	—	—	L.
—	1844	Nov. 11	,, *b* . .	—	—	G. 1 76 19·2	—	14·077	L. *See* XXXIV.
—	,,	,,	,,	—	—	G. 2 76 21·0	—	—	
27	1843	March 11	Niagara village . . .	43 15·0	79 8·0	F.A. 74 45·6	F.A. 1·8302	13·852	L.
28	,,	March 14	Rochester, N.Y. . . .	43 10·0	77 46·0	F.A. 74 41·0	F.A. 1·8062	13·670	L.
29	,,	March 25	Springfield, Mass. . . .	42 1·0	72 36·0	F.A. 73 39·7	F.A. 1·7677	13·379	L.
30	,,	April 16	Coburg, C.W. . . .	43 56·0	78 10·0	F.A. 75 27·2	—	—	H.
31	,,	April 17	Belleville	44 9·0	77 25·0	F.A. 77 1·0	—	—	H.
32	1845	June 13	Brockville	44 32·0	75 41·0	G. 1 76 19·8	L. 1 1·8110	13·707	Y.
—	,,	,,	—	—	..	G. 2 76 18·0	L. 2 1·8122	13·716	Y.

TABLE XIV.—*Observations in Canada and the United States.*—Continued.

No.				Latitude	Longitude	Dip	Relative intensity	Absolute intensity	Observer
33	1843	April 19	Prescott	44° 35′·0	75° 30′·0	F.A. 78° 42′·5	—	—	L.
34	,,	April 20	Williamsburg	44 55·0	75 7·0	G. 1 76 31·8	L. 1 1·8419	13·934	L.
—	,,	,,	,,	—	—	G. 2 76 29·8	L. 2 1·8489	13·994	L.
35	1845	June 16	Cornwall	45 2·0	74 50·0	G. 1 76 16·5	L. 3 1·8211	13·783	Y.
—	,,	,,	,,	—	—	G. 2 76 16·3	L. 4 1·8227	13·795	Y.
36	,,	Oct. 18	Niagara Falls	43 4·0	79 9·0	G. 1 74 46·8	L. 3 1·8172	13·754	L.
—	,,	,,	,,	—	—	—	L. 4 1·8181	13·761	L.
37	,,	Oct. 20	Buffaloe, N.Y.	42 55·0	78 54·0	G. 1 74 37·8	L. 3 1·8095	13·696	L.
—	,,	,,	,,	—	—	—	L. 4 1·8092	13·693	L.
38	,,	Oct. 22	Amherstburg	42 6·0	83 3·0	G. 1 73 32·7	L. 3 1·8188	13·766	L.
—	,,	,,	,,	—	—	G. 2 73 27·2	L. 4 1·8173	13·755	L.
39	,,	Oct. 25	Sarnia	42 58·0	82 22·0	G. 1 74 18·6	L. 3 1·8241	13·806	L.
—	,,	,,	,,	—	—	—	L. 4 1·8255	13·816	L.
—	,,	Oct. 27	,,	—	—	G. 2 74 12·9	L. 3 1·8253	13·815	L.
—	,,	,,	,,	—	—	—	L. 4 1·8231	13·798	L.
40	,,	Oct. 28	Goderich	43 45·0	81 41·0	G. 1 75 4·4	L. 3 1·8281	13·836	L.
—	,,	,,	,,	—	—	—	L. 4 1·8258	13·825	L.
—	,,	,,	,,	—	—	G. 2 75 5·3	L. 3 1·8271	13·829	L.
—	,,	,,	,,	—	—	—	L. 4 1·8287	13·843	L.
41	1849	June 5	CINCINNATI	39 6·0	84 27·0	G. 1 70 28·8	L. 3 1·7902	13·550	L.
—	,,	,,	,,	—	—	—	L. 4 1·7895	13·544	L.
—	,,	,,	,,	—	—	G. 2 70 28·8	L. 3 1·7906	13·553	L.
—	,,	,,	,,	—	—	—	L. 4 1·7896	13·546	L.
42	,,	June 14	Mammoth Cave, Ky.	37 10·0	86 11·0	G. 1 69 18·7	L. 3 1·7716	13·409	L.
—	,,	,,	,,	—	—	G. 2 69 18·3	L. 4 1·7734	13·422	L.
43	,,	June 18	Louisville, Ky.	38 3·0	85 30·0	G. 1 69 56·2	L. 3 1·7930	13·570	L.
—	,,	,,	,,	—	—	G. 2 69 54·8	L. 4 1·7940	13·578	L.

1 The poles of Needle C were reversed at Sorel.

2 Not reversed.

3 Observation incomplete. An observation, also incomplete, on the 24th, gave 72° 40′·5, confirming the fact that the dip was less at the Lunatic Asylum, Manhattanville, than at Columbia College, in the City of New York. (*Phil. Trans.*, 1846, p. 330.)

4 Only two weights used at Dorchester.

5 The observation was repeated at Baltimore, at Dr. Nicolet's request, to verify observations of his own which indicated a slight degree of local attraction. The stations *a* and *b* were in St. John's Wood, about 300 yards apart. The last was at St. Mary's College. His results in August 1841, by a needle with poles reversed, were respectively, 71° 35′·9, 71° 50′·1 and 71° 39′·7 on the same spots.

6 This observation was made by Dr. Bartlett, with a needle by Gambey.

32. The dips at Kingston and Belleville, on Lake Ontario (Nos. 23–32), and at Prescott, on the St. Lawrence (No. 33), are among the most irregular recorded on the survey. By the mean direction of the isoclinal lines the dip should be less than 76° at each of these stations. We have, however, an unusual amount of confirmation at Kingston, where it was three times recorded. The station was at the then Artillery barracks, towards the centre of a large open parade, near the flagstaff.

		° ′	
1842. November 11, Gambey	1 . . .	77 18·8	Lefroy
" "	2 . . .	77 19·1	"
1843. April 18, "	1 . . .	77 18·1	"
1845. June 10, "	1 . . .	77 14·2	Younghusband
" "	2 . . .	77 14·7	"
Mean		77 17·0	

The anomalous value of the total force at this station rests in like manner on repeated observation.

1842. November 11, Artillery Square, Lloyd	A 1·9533	14·782	L.
" " "	B 1·9781	15·160	L.
1845. June 10, " "	C 1·9959	15·106	Y.
" " "	D 1·9971	15·115	Y.
June 11, Stewart's Point "	C 1·9164	14·471	Y.
" " "	D 1·9062	14·427	Y.
" Common near Penitentiary "	C 2·0498	15·478	Y.
" " " "	D 2·0418	15·453	Y.

These observations of force were omitted by Sabine, although he inserted the dip, and the evidence of local disturbance was therefore incomplete.

We have not to look far for a geological cause of the anomaly at Kingston. This region of Canada is highly metalliferous. There are numerous superficial deposits of iron ore in the counties of Hastings, Addington, and Frontinac, and it is now worked in several places.[1] They are, it is true, none of them very near Kingston, but this gives additional value to the proof thus afforded that the dipping needle may become a valuable instrument of geological research. At Brockville, about twelve miles west of Prescott, and at Cornwall, about forty-six miles east of that place, the anomaly disappears.[2]

[1] *See* Mr. Vennor's *Reports in the Geological Survey of Canada*, 1869, p. 143, and *ib.* 1870, p. 309.

[2] Although not connected with the magnetic survey of Canada, I take this

The intensity at Cincinnati, which was the base of Dr. Locke's survey, is a little less than Sabine made it in 1846 from three independent comparisons, one of them direct (but by means of the horizontal force only), the other two indirect. He deduced 1·795 ('Phil. Trans.,' 1846, p. 314). I found it 1·7900 in 1849. The difference is less than 0·003 of the quantity. In these observations I had the assistance of Captain, now General W. J. Smythe, R.A.

33.—Toronto. *Station A.*

It has been repeatedly mentioned that the intensity of the earth's magnetic force at Toronto in 1843–4 on the relative scale was,

1·8360.

As this is a physical datum of importance, affecting every value given in the present volume, it may be convenient to trace here the steps by which it was arrived at, and to remind the beginner in magnetism of what the figure signifies. Captain E. Sabine's important 'Report on the Magnetic Intensity of the Earth,' in the Seventh Report of the British Association (1838), is the source of the explanation.

Between the years 1798 and 1806 the illustrious Alexander von Humboldt, by means of needles transported from South America to Europe, determined the intensity at the Paris Observatory to be

opportunity of placing on record some unpublished determinations of the dip at Mount Langton, Bermuda, made by me in 1872, lat. 32° 18′, long. 64° 48′ W. The instrument was one lent by the Committee of Kew Observatory.

1872	Needle	α ° ′	β ° ′	Mean ° ′
November 5	No. 1 . . .	67 27·2	67 11·8	67 19·5
,, 5	,, 2 . . .	67 14·8	67 17·0	67 15·9
,, 6	,, 1 . . .	67 27·8	67 19·0	67 23·4
,, 6	,, 2 . . .	67 16·2	67 20·7	67 18·4
,, 11	,, 1 . . .	67 28·6	67 18·3	67 23·4
Mean . . .		. . .	. .	67 20·1

An identical result, 67° 20′, was obtained by Lieut. Bromley, R.N. of H.M.S. 'Challenger,' upon the same pedestal, in June following; but this officer discovered an unexpected amount of local variation in Bermuda, due doubtless to the presence of a deeply underlying volcanic formation, and to the large proportion of oxide of iron in the red soil in some places.

to that of the magnetic equator, or line of no dip, in Peru, as 1·3482 to unity. He erroneously supposed at the time that there was no lower intensity than what he took for unity; it is scarcely necessary to say that a force as low as 0·80 has since been found to prevail over a considerable tract of the South Atlantic, as it does not in any way affect the comparison. In 1827 the late Sir Edward, then Captain Sabine, R.A., determined the value at the Chiswick Horticultural Garden, near London, to be to that at Paris as 1·0180 to unity,[1] or to that in Peru as 1·3724 to unity.

It has been assumed that the intensity at Woolwich, thirteen miles east of Chiswick, is sensibly the same; and no correction has been applied for the secular change, if any, between 1827 and 1843–6. It may be inferred from the mean direction of the isodynamic lines that the force at Woolwich is a minute quantity less than it is at Chiswick, and subsequent observation has made it probable that the force in 1843–6 was a little greater than it was in 1827;[2] but as the same secular change would doubtless embrace Paris, the relation between the two places would not sensibly alter.

1·3720 then has been adopted as the force at Woolwich. Now the force at Toronto was ascertained by the writer's observations in 1842–6, which are very fully given in the 'Phil. Trans.,' 1846, to be to that at Woolwich as 1·3380 to unity, and therefore to the magnetic equator as 1·8357 to unity; or, as employed by Sabine, 1·8360.

But the force was also determined at Toronto in absolute measure, being in British F.S.G. units 13·896 (*ib*). Hence, to convert relative into absolute terms we have only to multiply by $\frac{13{\cdot}896}{1{\cdot}836}$, and these again may be converted to German M.S. Gr. units by multiplying by 0·46108.

The dip has been regularly observed at Toronto, with a circle by Robinson, several times a month from 1841 to the present time; but besides this continuous series, observations were occasionally made with the dip circle of the survey. I subjoin the results, with the mean of the Observatory series (R.) for the same month.

[1] *Phil. Trans.*, 1827, and Brit. Assoc., VIIth Report.

[2] *Ib.* 1870. The secular change in 17 years, at the rate of increase which prevailed from 1857 to 1862, would have been + ·0021, or about ·00013 ϕ. It has decreased since 1862.

			Gambey		Robinson	
			° ′		° ′	
1843. January 9,	G. 1 . . .		75 14·8	1	R. 75 14·5	H.
1845. May 30,	G. 1 . . .		75 13·8	1	75 15·3	Y.
,,	G. 2 . . .		75 11·7	1	,,	
1846. April 6–13,	G. 1 . . .		75 15·5	6	75 14·3	L.
,,	G. 2 . . .		75 15·9	5	,,	L.

The close accordance of these results leaves nothing to be desired. The mean for the mean epoch of this survey 1844·0 is 75° 14′·7.

The declination or variation at Toronto for 1844·0 was by reduction 1° 25′·5 W. The independent series of monthly determinations began January 1, 1845, but by the declinometer readings we have for 1843 mean 1° 24′·7 W.

1844 ,, 1° 26′·2 W.

DIARY.

SECTION I.

MONTREAL TO THE SAULT ST. MARIE.

About 530 geographical miles.

I. *September* 19, 1842.—On the *Island of St. Helen*, Montreal, near the then Artillery barracks. Lat. 45° 31′·1; long. 73° 31′ 42″ W.[1] (*see* Table, p. 52).

		°	′
Variation, 8.18 A.M.	By Compass, card A.	8	48·1 W.
„ 8.44 „	„ „ B.	9	7·0
Mean	.	8	57·6[2]

April 25–29, 1843.—At the same place.

	°	′
Dip, Gambey 1.4 P.M.	77	2·1
„ „ 2 „	77	8·6
Mean	77	5·3

Total Force	Relative	Absolute	*W.*
Sept. 16, Fox A . .	1·8128	13·720	(6·0)
April 25, „ A . .	1·8231	13·799	(6·0)
„ 28, Lloyd A . .	1·8215	13·786	(2·5)
„ 29, „ B . .	1·8102	13·701	(2·5)
Mean . . .	1·8166	13·755	(1·7)

These values have been explained at p. 56. They signify that, assuming the force at Toronto to be 1·836, the force at St. Helen's by Fox A was 1·818, and assuming the force at Fort William to be 1·860 (*see* Station LXIX), the force at St. Helen's was by Lloyd's static needle A 1·8215, and by needle B 1·8102. The mean of the whole is 1·817, equivalent to 13·755 in absolute measure. The column *W.* signifies *weight* (*see* p. 41). These remarks explain all future entries.

[1] Deduced from the longitude of Viger Square, ascertained by Captain E. D. Ashe, R.N., in 1857, to be 73° 32′ 55″, or 4h 57m 12s W. See *Geological Survey of Canada*, 1857, p. 239.

[2] This was a marine compass used on board the 'Prince Regent' Transport in my voyage to Quebec. See *Phil. Trans.*, 1849, p. 191. It was exchanged in April for another instrument.

II. *April* 30.—At the *Isle d'Urval* or *Dorval*, nearly opposite La Chine. Lat. 45° 25′; long. 73° 44′ W.

		°	′
Dip P.M., Gambey No. 1	. . . . .	77	6·1 [1]
Correction for non-reversal	. .	–	3·0
Corrected	. . . . . .	77	3·1

Total Force	Relative	Absolute	W.
Fox A	1·8058	13·667	(6·0)
Lloyd A	1·8044	13·658	(2·5)
" B	1·7940	13·578	(2·5)
Mean	1·8028	13·645	(1·1)

There is local disturbance at this station.

May 1.—The canoes started from Isle d'Urval this day, under Mr. John Maclean, a chief trader of the Hudson's Bay Company, and no opportunity of observation was presented.

III. *May* 2.—Proceeded up the Ottawa, and observed about three miles below the rivulet called the R. la Graise, on the farm of one *La Combe*, W. bank. Lat. 45° 33′; long. from the map 74° 9′ W.

	°	′
Variation at 5.30 A.M.	8	26·0 W.
Dip, Gambey No. 1 (not reversed) .	76	50·6

Total Force	Relative	Absolute	W.
Fox A	1·8334	13·876	(6·0)
Lloyd A	1·8249	13·812	(2·5)
	1·8302	13·855	(0·85)

IV. Observed again at the camp on an island in the Ottawa, about six miles above R. la Graise. Lat. by Polaris 45° 37′ 36″.

V. *May* 3.—At *Carillon*, at the east end, or entrance of the Grenville canal, left bank. Lat. from the map 45° 36′; long. 74° 30′.

Variation, 6.45 A.M. . . . . . 8° 41′ W.

VI. Same day at noon, near *Chatham*, observed. Lat. 45° 35′ 12″.

VII. Same day at *Pointe du Chêne*, left bank, about four miles beyond the upper end of the Grenville canal (*Longueisle* was about three miles distant S.E. *b* E.). Lat. 45° 37′; long. 74° 50′.

	°	′
Variation, 6.40 P.M.	7	28 W.
Dip, not reversed	76	55·4

[1] Formerly published 77° 21′·1, and omitted from Lieut.-Colonel Sabine's map as a station of local disturbance, which indeed it is, but there was a clerical error in the dip given.

Total Force	Relative	Absolute	W.
Fox A	1·7974	13·604	(6·0)
Lloyd A	1·8057	13·667	(2·5)
	1·7984	13·622	(0·85)

These values indicate local disturbance.

VIII. *May* 4.—On Lot 32, *Alfred Township*, right bank. Lat. 45° 37′; long. 75° 0′.

Variation, 8.0 A.M. . . . . . 6° 58′ W.

IX. Same day, at *Foxe's Point*, right bank. Lat. about 45° 32′; long. 75° 22′.

Dip, not reversed . . . . . . 76° 35′·3

Total Force	Relative	Absolute	W.
Fox A	1·8369	13·903	(6·0)
Lloyd B	1·8254	13·816	(2·5)
	1·8335	13·877	(0·85)

X. *May* 5.—On the farm of *W. Templeton*, left bank, about six miles below Bytown (now Ottawa), probably the place now called Templeton. Lat. 45° 29′; long. 75° 36′. Ottawa is one of the places the longitude of which has been ascertained by telegraph 75° 42′ 4″, the place of observation being on Barrack Hill, 120 yards E. of the flagstaff (Captain Ashe).

Variation, 7.30 A.M. . . . . . 8° 28′ W.

XI. Same day at *Aylmer*, left bank, twelve miles above Bytown; the spot was about 60 yards S.E. of the only inn in the place. Lat. by Polaris 45° 15′; long. 75° 58′.

Dip (poles reversed, as is the case in all the observations that follow) . . . . 76° 41′

Total Force	Relative	Absolute	W.
Lloyd A . .	1·8280	13·836	(0·25)

Sir George Simpson, the Governor of the Hudson's Bay Company, here overtook and passed the Brigade on his way to the interior. By his authority Mr. Maclean adopted a new arrangement. He placed at my disposal the services of two young *voyageurs*, named Edouard Genereux and Pierre Roubillon, to carry the instruments over Portages, pitch my tent, and be otherwise useful, and the canoe in which I had my passage was detached, with a view to give me time to complete observations. It was an improvement on the previous arrangement, but still very insufficient. It proved in fact impossible to reconcile the necessities of observation with the rapidity of advance indispensable to the Brigade. We were a constant source of anxiety, as any accident to us would have involved much inconvenience and delay to the whole expedition. This arrangement lasted no further than Fort William.

XII. *May* 6.—At the *Chat Falls* or *Portage des Chats.* Lat. adopted 45° 26′; long. 76° 32′.

Dip, Gambey 1, midday . . . . . 75° 7′·0

Total Force	Relative	Absolute	*W.*
Fox A . .	1·8481	13·988	(6·0)
Lloyd B . .	1·8337	13·879	(2·5)
	1·8418	13·916	(0·85)

XIII. *May* 7.—At the *Portage du Fort.* Lat. adopted 45° 36′; long. 76° 53′.

Variation, 8 A.M. . . . . . 10° 11′ W.[1]

This observation, taken in connection with the abnormal dip and force at the preceding station, which was about seventeen miles distant, indicates a considerable degree of magnetic disturbance in this part of the Ottawa.

XIV. Same day at noon at the *Décharge d'Argile.* Lat. observed 45° 39′ 36″.

XV. Same day at the south end of the *Portage de Grande Calumet,* opposite Callumette Island. Lat. 45° 45′; long. 76° 40′.

Dip, Gambey 1, P.M. . . . . . 76° 44′·4

Total Force	Relative	Absolute	*W.*
Fox A	1·8276	13·832	(0·6)

XVI. *May* 8.—Arrived at FORT COULONGE. By observation at noon. Lat. 45° 54′ 54″; long. 76° 45′.

	° ′
Dip Gambey 1	77 29·7[2]
Fox A gave	77 16·7

Total Force	Relative	Absolute	*W.*
Fox A . .	1·8392	13·920	(6·0)
,, C . .	1·8384	13·914	(4·0)
Lloyd A . .	1·8424	13·951	(2·5)
	1·8380	13·911	(1·25)

Fox's needle C, here first available, is reduced to Fort William as a base, with value 1·8601 (*see* Station LXIX).

[1] Formerly published 5° 11′ W. (*Phil. Trans.*, 1872, p. 382). The original sights being lost, I cannot verify the calculation, but I give the value as it stands in my MS., and which I believe to be correct as observed.

[2] This dip may be slightly in excess; the instrument was noticed at the end to be a little out of the meridian.

XVII. *May* 9.—At *Pointe Baptême*, about ten miles above *Fort Allumette*, or *Fort William* on some modern maps. It is apparently in the township of Esher. Lat. from a map 46° 5′; long. 77° 26′.

Dip, Gambey 1, 3 P.M. . . . . . 77° 19′·1[1]

Total Force	Relative	Absolute	W.
Fox A . .	·1·8200	13·775	(0·6)

XVIII. *May* 10.—Upper end of the *Portage des Deux Juachims*. By observation at noon. Lat. 46° 12′ 4″; long. 77° 40′.

Dip Gambey 1, 11 A.M. . . . 77° 3′·8

Total Force	Relative	Absolute	W.
Fox A . .	1·8265	13·824	(6·0)
Lloyd A . .	1·8290	13·843	(2·5)
	1·8272	13·830	(0·85)

XIX. Same day.—At the *Portage du Roche Capitaine*. By Polaris. Lat. 46° 15′; approximate long. 77° 45′.

From this date onwards my original sights have been preserved, and, with a few exceptions, where they have become illegible, have been gone over and re-worked.

May 11.—Before leaving the last camp observed:

		° ′
Variation, 5.10 A.M.	. . . . .	5 25·8 W.
„ 5.16 „ .	. . . . .	4 51·9
Mean	. . . . . .	5 8·8

XX. Same day.—On halting for breakfast in the township of Aberdeen. Lat. by account, 46° 14′; long. 77° 50′.

Variation at 8.15 A.M. . . . . . 5° 33′ W.

XXI. Same day.—About three miles above the *Portage des Deux Rivières*, in the township of Aberford. Observed Lat. 46° 15′ 26″.

XXII. Same day.—At the *Trou Portage*, left bank, in the township of Labouchere. Lat. 46° 15′; long. 78° 16′.

Dip, Gambey 1 P.M. . . . . . 77° 24′·4.

Total Force	Relative	Absolute	W.
Fox A	1·8422	13·943	(6·0)
Lloyd A . . .	1·8348	13·886	(2·5)
	1·8400	13·914	(0·85)

[1] Previously published 75° 16′ by a clerical error, and omitted by Sabine from his map.

XXIII. *May* 12.—At the Hudson's Bay Company's house, at the junction of the *Mattawa* or '*Little River*' with the Ottawa. Lat. 46° 18′; long. 78° 42′ 29″. (Dominion Survey Department.)

Variation, 7.20 A.M. . . . . . 3° 36′·2 W.

XXIV. Same day.—At the *first portage* on the *Little River*, about three miles from the last station. By observation at noon. Lat. 46° 15′ 26″ ; long. 78° 44′.

Dip, Gambey 1 . . . . 77° 28′·5.

Total Force	Relative	Absolute	W.
Fox A	1·8474	13·984	(6·0)
Lloyd A	1·8356	13·893	(2·5)
	1·8439	13·956	(0·85)

XXV. *May* 13.—Observed at noon on *Lake Temisique*. Lat. 46° 19′ 4″.

The name of this station does not occur on the map which accompanies the Report of the Geological Survey for 1855. We have instead, Lake de Talon, sometimes called Lake Walrond; and a little to the westward of it, Lower Trout Lake. They are in the same latitude; and the last-named is what I called Lake Temisique.

XXVI. Same day.—On the south side of *Trout Lake*, formerly called Lake de Grande Vase, from the name of the portage at the foot of it. Lat. 46° 18′·5 ; long. 79° 13′.

Dip, Gambey 1 P.M. . . . . . 77° 21′·7.

Total Force	Relative	Absolute	W.
Fox A	1·8425	13·945	(6·0)
Lloyd A	1·8445	13·960	(2·5)
	1·8431	13·949	(0·85)

XXVII. Same day.—Encamped at the *Portage de Grande Vase*, towards the middle of it. Lat. by observation of Polaris, 46° 19′ 32″ ; long. 79° 20′.

Variation, 6.7 P.M. . . . . . 3° 15′ W.

XXVIII. *May* 14.—At the west end of the same portage, being the one leading to the small stream by which we reach Lake Nipessing in about three miles. Lat. 46° 18′ ; long. 79° 22′.

Variation, 7.47 A.M. . . . . . 4° 53′·4 W.

We entered *Lake Nipessing*, the height of which above the sea is 665 feet, at 9·10 A.M.

XXIX. Same day.—Observed at noon on the south side of the lake, at a spot marked by a cross, erected to commemorate some fatal accident. Lat. 46° 11′ 54″.

XXX. Same day.—A few miles further westward. Lat. 46° 11′; long. 79° 48′.

Dip, Gambey No. 1 P.M. . . . . 77° 9′·5.

Total Force	Relative	Absolute	W.
Lloyd A	1·8313	13·861	(0·25)

XXXI. *May* 15.—On French River, about twenty-five miles from the lake. Lat. 46° 5′; long. 80° 20′.

Variation, 8.0 A.M. . . . . 5° 32′·1.[1]

XXXII. Same day.—On French River, about ten miles above the Ricollet's Fall. Lat. 46° 2′ 9″.

XXXIII. Same day. At the *Ricollet's Fall*. Lat. 45° 57′; long. 80° 30′.[2]

Dip, Gambey 1, 2 P.M. . . . . . 76° 45′·4.

Total Force	Relative	Absolute	W.
Fox A	1·8716	14·165	(6·0)
Lloyd A	1·8653	14·118	(2·5)
	1·8697	14·130	(0·85)

This result indicates a considerable amount of local disturbance. The formation is noted as a syenitic gneiss.

XXXIV. This is the place to introduce, out of the order of time, observations at *Penetanguishene*, on Lake Huron, the last of my stations, being the place at which I landed on my return to Canada, November 15, 1844. Lat. 44° 49′; long. 80° 1′.

Variation *not observed*.

	°	′
Dip (*See* Table XIV., p. 53, for an observation in Jan. 1843, 76° 4′·2[3])		
Gambey No. 1	76	19·2
No. 2	76	21·0
	76	20·1

See also Table XIV.

[1] This result being apparently about 2° too much, I have reduced the sights separately; they are consistent, within usual limits. There is evident local disturbance.

[2] Longitudes between Lakes Nipessing and Huron have been corrected by a map annexed to the Geological Survey of 1845-6.

[3] The observation on Jan. 26, 1843, was taken 'near Mrs. Wallace's Inn,' a quarter of a mile south of the barracks. The observation of November 11, 1844, was taken in front of the 'Freemasons' Arms Inn.' Whether these were the same, I cannot now say. The difference seems to indicate a different locality, a mean of 76° 12′ would best agree with the isoclinal.

Absolute horizontal force by vibration only :—

	Corrected T s	m	X	φ	W.
Magnet No. 30	4·0551	0·3951	3·3218	14·061	(1·0)
,, ,, 31	4·3324	0·3505	3·3218	14·061	(1·0)
,, ,, 17	4·5047	0·6397	3·3235	14·110	(1·0)
			3·3224	14·077	(0·3)

In relative terms 1·8600.

The same bars being vibrated again at Toronto, Station A, shortly afterwards, serve to connect that station with all the others.[1]

		Corrected T s	m	X	φ	W.
January 29, 1845.	No. 30	3·9463	0·3928	3·5281	13·896	(1·5)
February 5, ,,	,, 31	4·2041	0·3495	3·5399	13·911	(1·5)
March 8, ,,	,, 17	4·3856	0·6363	3·5358	13·894	(1·5)
				3·5346	13·900	(0·45)

The mean value of the horizontal force for 1845 by twelve months' observation with the Observatory instruments was 3·5380 (Sabine, p. 244). That of the total force taken throughout as standard is 13·896, differing from the above by less than 0·0001, of the amount, the dip employed being 75° 15′·5.

XXXV. *May* 16, 1843.—We were detained for some hours by wind on one of the small islands in Lake Huron, lying off the mouth of French River, a little to the N. A cross was erected to mark the spot, and hence it is called *Pointe au Croix*; but this mark has doubtless disappeared. The island can probably be identified on the spot by its proximity to the main channel of the river.

By observation at noon, lat. 45° 55′ 31″, long., from the most recent chart, 81° 2′ W.; Lake Huron is 580 feet above the sea.

Dip, Gambey No. 1. . . . . 76° 31′·3

Total Force	Relative	Absolute	W.
Fox A . .	1·8394 [2]	13·928	(5·0)
,, C . .	1·8323	13·868	(4·0)
Lloyd A . .	1·8477	13·985	(2·5)
	1·8369	13·903	(1·15)

[1] Toronto, lat. 43° 39′·4; long. $5^h\ 17^m\ 33^s$; above the sea, 342 ft. *See* p. 56.

[2] The angle of deflection with 2·5 grains gives the anomalous value 1·888, and I reject it.

XXXVI. *May* 17.—Left the last station at 3 A.M., observed on the east shore of the lake at a point about eighteeen miles from French River, which agrees in position with *George's Island.*

Lat. by account, 45° 57′; long. 81° 32′ W.

Variation 7.39 A.M. . . . . 1° 25′·6 W.

XXXVII. Same day.—Observed at noon, in *Frazer Bay*, lat. 45° 57′ 24″.

XXXVIII. Same day, about 2 P.M., also within *Frazer Bay*, lat. 46° 0′; long. 81° 40′.

Dip, by Gambey No. 1. . . . . . 77° 5′·6

Total Force	Relative	Absolute	W.
Fox A . .	1·8375	13·907	(6·0)
Lloyd A . .	1·8371	13·905	(2·5)
	1·8373	13·906	(0·85)

XXXIX. Observed at the camp, in longitude *cir* 81° 47′. Lat. by Polaris, 46° 4′ 57″.

XL. *May* 18.—Reached the Hudson's Bay establishment, called *Fort la Cloche*, at an early hour. It takes its name from the Island of La Cloche, which is some ten miles distant to the S.E., and the latter preserves the memory of some early missionary establishment of the Jesuits. The latitude was observed on my return voyage, on November 7, 1844. By Polaris 46° 7′ 0″; long. 82° 3′.

Variation, May 18, 1843, at 8.33 A.M. . . . . 2° 10′ W.
Dip by Gambey November 8, 1844 . . . . 76° 50′·2
Force *not observed.*

XLI. Observed the latitude a little beyond the Fort to the W. (May 18), 46° 8′ 37″.

XLII. Observed again on *Snake Island.* Lat. by account 46° 10′; long. 82° 40′.

Dip by Gambey No. 1. . . . . . 77° 5′·5.

Total Force	Relative	Absolute	W.
Fox A . .	1·8291	13·844	(6·0)
Lloyd A . .	1·8320	13·865	(2·5)
	1·8300	13·850	(0·85)

The stations of my return voyage in 1844 here begin to come in between stations of the outward voyage of 1843, and will be numbered in geographical order, as one series; but to make a distinction, the dates in 1844 follow the entries.

XLIII. *May* 19.—Observed near the mouth of the *River Mississaqui.* Lat. by account 46° 10′; long. 83° 2′.

Variation, 7.45 A.M. . . . . . . 2° 12′·7 E.

XLIV. At *Cranberry Bay.* Lat. by Polaris 46° 10′ 41″; long. 82° 53′. Observed the azimuth of the star *a* Aquilæ, which was favourably situated in the west, referring the angle by a theodolite to the axis of collimator magnet No. 6.

	°	′	″	
Star from true meridian	124	7	12	W.
„ „ magnetic meridian . .	123	41	50	W.
Whence variation at 7.20 P.M. .	0	25	22	W.

November 6, 1844.

XLV. *May* 19.—Observed at noon. Lat. 46° 15′.

XLVI. Observed again at *Tessalon Point,* a long promontory at the mouth of the small river of that name. Lat. 46° 17′; long. 83° 33′.

	°	′	
Variation by compass, 3.26 P.M	0	11·4	W.
Dip by Gambey No. 1	76	59·3	
Fox A	77	4·8	

Total Force	Relative	Absolute	W.
Fox A	1·8581	14·063	(6·0)
Lloyd B	1·8390	13·919	(2·5)
	1·8525	14·020	(0·85)

XLVII. At a spot in St. Mary's River called *Bear Camp* (*Campement d'Ours*), reckoned about eight leagues or twenty-four miles below the Sault and sixteen miles from Tessalon Point. It is on the mainland, facing St. Joseph's Island, E. end. Lat. by Polaris 46° 20′ 15″; long. 83° 50′. By an observation of *Capella*, E.

	°	′	″	
Star from true meridian	54	7	33	E.
„ „ magnetic meridian . . .	54	5	0	
Whence variation at 7.59 P.M. . .	0	2	30	E.

November 5, 1844.

XLVIII. *May* 20.—At a spot on *Sugar Island*, in St. Mary's River, about five miles below the Sault. Lat. by chart, 46° 29′·7; long. corrected, 84° 17′.

	°	′
Sun from true meridian	95	33
„ „ magnetic meridian	94	29·4
Variation at 7.46 A.M.	1	3·6 E.

XLIX. We arrived soon after at the *Sault de St. Marie*, 'St. Mary's' of modern maps, but made no stay upon this occasion. It was the practice of the outward-bound brigades to proceed on without delay to the next station, to avoid the temptation to desertion, and the facilities for obtaining spirits, afforded by the American frontier settlement on the opposite side of the river. I had abundant evidence of the necessity for this precaution on my return, in the death of Narcisse Arel, one of my crew, from apoplexy, the result of intoxication. The following observations were, however, then made: latitude 46° 30′ 44″, being 12″ less than the latitude of the Michigan State Survey, which is 46° 30′ 56″. For the longitude I adopt that of the Michigan Survey of 1867, namely, 84° 21′ 33″, or $5^h\ 37^m\ 46^s{\cdot}2$ W., although it is about 12′ to the East of the position on Bayfield's original chart, Sheet III. It agrees, however, very nearly with Franklin, who gives 84° 23′ 7″,[1] and has been adopted in the revised chart of Lake Superior.

Variation by collimator No. 6, November 4, 1844:—

	°	′
At 9.56 A.M.	1	14·1 E.
10.5 A.M.	0	51·1 E.
11.5 A.M.	1	8·2 E.
Mean	1	1·1 E.

The theodolite was carefully examined and readjusted between the second and third observation.

Lieutenant Lee, of the United States Topographical Engineers, obtained variation 0° 4′ 25″ W. in July 1873,[2] his station being

[1] I am indebted to the courtesy of His Excellency the Governor of the State of Michigan for a Report from Professor O. B. Wheeler, of the Lake Superior Survey, on the latest determination of longitude as laid down on the United States Chart of Lake Superior, No. 1, 1872, and reduced to my station on the British side. These American corrections, as remarked above, have been adopted on the new Chart of Lake Superior, issued by the Admiralty in 1878, No. 320, of which I have only become aware since these pages were written.

[2] See Appendix D of Appendix CC of the Report of the Chief Engineer, Michigan. 1874.

273 feet N.W. of the flagstaff of Fort Brady, whence it would appear that the line of No Variation moved W., increasing westerly and decreasing easterly variations in this quarter, between 1844 and 1872, at the apparent rate (disregarding horary corrections) of 2′·4 per annum; and on turning to the Toronto observations for the interval,[1] we find that the change was continuous and uninterrupted, but with acceleration from 1869.

The dip was observed by my assistant, Corporal Henry, on November 4, 1844, but from some cause unexplained, probably the instrument not being in the meridian, the results are unquestionably wrong, and must be rejected. He made it

	°	′
By Gambey No. 1	77	46·2
" " 2	77	45·6

Dr. John Rae observed it in May 1845, and records the true value, 77° 19′·5.

Horizontal force in absolute measure, November 4, 1844:[2]

	Corrected T s.	m	X	Total	W.
No. 30	4·2527	0·3940	3·0289	13·804	(1·5)
" 31	—	0·3517	3·0311[3]	13·814[3]	(0·8)
" 17	4·7196	0·6393	3·0387	13·849	(1·5)
			3·0330	13·824	(0·38)

L. *May* 20 (*continued*).—The canoes leaving the Sault pushed on to the customary camp at *Pointe aux Pins*, about seven miles W.S.W. from the Fort. Latitude by observation of Polaris 46° 29′ 52″; longitude by the recent chart, 84° 29′.

	°	′
Dip, Gambey No. 1	77	13·4
The angles by Fox gave . . .	77	12·1

Total Force	Relative	Absolute	W.
Fox A . .	1·8655	14·119	(6·0)
Lloyd A . .	1·8516	14·014	(2·5)
" B . .	1·8571	14·056	(2·5)
	1·8603	14·080	(1·1)

[1] *See* abstracts and results of magnetical and meteorological observations at the Magnetical Observatory, Toronto, Canada, from 1841 to 1871. [By Professor G. T. Kingston], Toronto, 1875.

[2] Sabine includes an observation by Dr. Locke taken on the American side. He makes the mean dip 77° 24′·9, and the force 13·98. It is wrongly inserted on the map as 77° 5′·3.

[3] From two values of $\frac{m}{X}$ by deflection, the unhappy event above referred to having interrupted the observation. The result is given half weight.

SECTION II.

SAULT STE. MARIE TO LAKE WINNIPEG.

About 925 geographical miles.

LI. *May* 21.—Entered Lake Superior and observed at *Pointe au Crêpe*, in a bay south of the headland called Mamainse, where we were detained by wind. Latitude by chart 46° 58′; long. 84° 44′. (By Bayfield, 84° 54′.)

	° ′
Variation, 5.8 P.M. . . .	3 2·8 E.
Dip 2 P.M., by Gambey . .	77 11·5

The results by Fox's needle A being very anomalous, although consistent among themselves. I give them for each weight, as observed, and reduced to temperature 46°·0.

Total Force		Relative	Absolute	
2·5 grains .	1·9115			
3·0 „ .	1·9287			
3·5 „ .	1·8996			
4·0 „ .	1·9128			
		1·9134	14·482	*Rejected*
By Lloyd A .		1·8443	13·959	

I cannot explain the discrepancy and omit this station. We encamped at the mouth of Montreal River.

LII. At *Cape Gargantua*, where I was detained in 1844 by wind. Latitude by observation at noon 47° 36′ 53″; long. 85° 5′. (By Bayfield 85° 15′.)

	° ′
Variation by collimation 2.15 P.M. . .	0 38·0 E.

The variation was about 30 scale divisions, or 1° 3′ more easterly next morning. The hour is not noted.

	° ′
Dip by Gambey No. 1	77 56·1

Horizontal force in absolute measure:—

	Corrected T s.	m	X	φ	W.
Bar 30	4·1408	0·3956	3·1816	15·223	(1·0)
„ 31	4·4156	0·3507	3·1960	15·290	(1·0)
„ 17	4·6015	0·6404	3·1924	15·273	(1·0)
			3·1900	15·265	(0·3)

This is the greatest force anywhere observed.

These observations concur in showing a very large amount of local disturbance, as was experienced at many of the stations on this lake, and is referrible to the volcanic nature and very disturbed condition of the formations on the east and north sides of the basin of Lake Superior. Hereabouts an amygdaloid prevails.[1]

May 22.—No observation possible. We arrived at a late hour at Michipicoton.

LIII. *May* 23.—At the Hudson's Bay Post, MICHIPICOTON, to which I also returned on October 29, 1844. By 'Polaris,' October 29, lat. 47° 56′ 2″; long. 84° 54′. (By Bayfield 85° 4′.)

	° ′
Variation by collimator October 30, at 9·55 A.M.	0 20·3[2]
Dip by Gambey No. 1, May 23, 7 A.M. .	78 6·3
„ Fox A	78 4·4
„ Gambey No. 1, October 30, 1844 .	78 8·1
„ „ No. 2 „ „ .	78 8·5
Mean	78 7·2

Total Force	Relative	Absolute	W.
Fox A, 1843 . .	1·8512	14·011	(6·0)
Lloyd B. . . .	1·8615	14·089	(2·5)
	1·8545	14·034	(0·85)

Horizontal force 1844:—

	Corrected T s.	m	X	φ	W.
No. 30	4·3598	0·3957	2·8693	13·957	(1·0)
„ 31	4·6507	0·3507	2·8810	14·014	(1·0)
„ 17	4·8606	0·6404	2·8600	13·917	(1·0)
			2·8701	13·962	(0·3)

Allowing proportionate weight to the two results the mean is 1·8522 or 14·015.

[1] See *Geology of Canada*, 1863, p. 702.

[2] This observation was previously published as 3° 49′ E., but on re-examination proves to have been reduced without applying the equation of time, which is $16^m\ 11^s$, hence a large error.

LIV. *May* 23 (*continued*).—We left the Fort a little before noon. The sun had passed the meridian 25m before an opportunity offered for landing. Latitude reduced to the meridian 47° 54′ 54″.

LV. Landed again about one mile east of the *Chienne River*. Lat. 47° 58′; long. 85° 16′.

Variation, 4.35 P.M.	. .	2° 16′·5 E.	
„ 5.33 „	. .	2 26·0	2° 21′·0 E.

We encamped about five miles further on.

LVI. *May* 24.—Observed at *Le Petit Mort*, a headland opposite Michipicoton Island. Lat. by chart 47° 56′; long. 85° 40′.

Variation, 7.40 A.M. . . . . 3° 59′·7 E.

LVII. The same day observed latitude at noon from the Lake Horizon 48° 4′ 27″.

LVIII. Landed again on the east side of *Otter Island* towards the S. end. Lat. by chart 48° 7′; long. 86° 7′.

Dip by Gambey No. 1, 1½ P.M.	. . .	79° 43′·6
„ *Fox A gave*	. . . . .	79 32·8

Relative Total Force	Relative	Absolute	W.
Fox A	1·7839	13·502	(6·0)
Lloyd A	1·8142	13·728	(2·5)
	1·7928	13·568	(0·85)

These results are somewhat discordant, but concur in showing the presence of great local disturbance, and we learn from the geological survey that an immense volume of trap rock breaks through the sandstones and chloritic schists at *L'Anse à la Bouteille* (LXII), and again crops out at Michipicoton Island, a little to the south of Otter Head (*see again* LXIII).

We camped this night at a small bay in latitude 48° 24′, *Oiseau Bay* on the chart of 1878.

LIX. A station of detention in 1844, a mile or two south of a stream called by the voyageurs *Rivière Blanche*, probably White-mud River on the same chart. Lat. about 48° 30′; long. 86° 14′.

Here I was kept by stress of weather from October 23 to October 26, and imperfectly observed the Göttingen Term day, which began at 3.36 P.M. of local mean time; observations were continued half-hourly from 9 A.M. 23rd to 8 A.M. of the 26th. The spot was tolerably sheltered, but the weather was most inclement, the wind being very high, with repeated falls of rain or snow.[1]

No other observations could be taken.

LX. At the White River, White-mud River, or *Rivière Blanche* of the voyageurs. I was detained at this spot from the 21st to the morning of October 23, when an ineffectual effort was made to proceed, which resulted in my being again forced to land at the station last mentioned. Half-hourly observations were made here from 10 A.M. on the 21st to 7 A.M. on October 23. Lat. by observation at noon 21st, 48° 31′ 39″; longitude by the revised chart 86° 14′.

	°	′
Variation, October 21, 3.51 P.M.	2	15·2 E.
Dip 1–2 P.M., Gambey No. 1	78	33·7
„ „ „ 2	78	32·5
Mean	78	33·1

Horizontal force in absolute measure by vibrations only, October 21:—

	Corrected T s.	m	X	φ	W.
No. 30	4·4104	0·3960	2·8018	14·116	(1·0)
„ 31	4·7096	0·3508	2·8086	14·150	(1·0)
„ 17	4·9150	0·6407	2·7957	14·085	(1·0)
			2·8020	14·117	(0·3)

LXI. *May* 25.—At the Hudson's Bay post at the mouth of the Pic. Latitude by observation at noon on October 17, 1844, 48° 35′ 20″; long. 86° 15′.

	°	′
Variation by collimator October 18, 10.38 A.M.	5	13·3 E.
„ „ „ 11.6 „	5	52·5 „
	5	32·9 „

	°	′	
Dip, May 25, 1843, by Gambey No. 1, A.M. .	78	45·8	
„ „ by Fox	78	40·8	
			78 43·3
Dip, October 17, 1844, by Gambey No. 1, A.M. .	78	32·8	
„ „ „ 2 . .	78	29·9	
			78 31·3
By Dr. J. Rae in May, 1845			78 34·0
Mean of the whole			78 36·6

[1] *See* p. 11 for the movements observed.

	Total Force Relative	Absolute	W.
May 25, 1843, by Fox A	1·8373	13·906	(6·0)
Lloyd A	1·8511	14·010	(2·5)
	1·8413	13·936	

Horizontal force in absolute measure, October 17, 1844, by vibrations only:—

Dip applied . . . . . . 78° 36′·6.

	Corrected T	m	X	φ	W.
	s.				
No. 30	4·4726	0·3961	2·7237	13·792	(1·0)
„ 31	4·7741	0·3508	2·7355	13·852	(1·0)
„ 17	4·9833	0·6408	2·7193	13·769	(1·0)
			2·7262	13·804	(0·3)

Allowing proportionate weight to the two results, the mean is 1·8366 or 13·901.

The large difference between the total force as determined in 1844 and the value found in 1843, results from the difference of the dip; for if the same horizontal force is reduced with the dip recorded in 1843, the resulting value is nearly the same as before, viz. 13·926. As compared, however, with the stations preceding and following (Sabine's, Table XL), the horizontal force itself appears too low, the time of vibration of each bar being very sensibly prolonged.

	Beyond Les Petits Ecrits Oct. 14.	Pic Oct. 17.	White R. Oct. 21.
	s.	s.	s.
Bar 30	4·1192	4·4726	4·4104
„ 31	4·3988	4·7741	4·7096
„ 17	4·5875	4·9833	4·9150
Dip	78° 24′	78° 31′·3	78° 33′·1

The vibrations were observed from 8.32 to 10 A.M., the dip about noon. There is no indication of any considerable change of force in the observations at Toronto (3^h to 7^h Gött, M.T.), but a state of disturbance is clearly indicated by the readings recorded.

LXII. *May* 25, 1843.—Left the Pic shortly before noon, and observed for latitude on an islet off the mouth of the river. The Fort, bearing E.*b* S., did not appear more than two or three miles distant. By reduction to meridian, lat. 48° 38′ 46″. The main body of the Brigade, which had pushed on while I was thus engaged, was forced by the heavy sea to land on Pic Island, where I rejoined them after a hazardous passage. About 5 o'clock we got off, and camped at *L'Anse à la Bouteille*, the promontory opposite Slate Island, so named in the original, but not in the later chart.

May 26.—No observations were made.

LXIII. Observed on what must from its situation have been *Battle Island* of modern charts. It is only noted by me as about six leagues west of Les Petits Ecrits. Lat. by chart 48° 45′; long. 87° 33′.

Dip by Gambey No. 1 . . . 76° 24′·0.[1]

Horizontal force by vibrations only :—

	Corrected T s.	*m*	*X*	*ϕ*	*W.*
Bar 30	4·1192	0·3962	3·2104	13·650	(1·0)
„ 31	4·3988	0·3509	3·2185	13·684	(1·0)
„ 17	4·5875	0·6409	3·2083	13·644	(1·0)
			3·2124	13·659	(0·3)

These observations concur in showing an extraordinary amount of local disturbance, the dip differing more than −2° from its normal value; parallel cases will be found in the magnetic survey of Scotland, at Oban, and Loch Scavig.

October 14, 1844.

LXIV. *May* 27.—Observed at a station which is only entered under the general designation of 'La Terre Platte,' and which I cannot precisely identify. It appears, however, to have been on what is now called *Simpson's Island*, not named in 1843. Lat. 48° 49′, long. *about* 87° 45′.

The term *Terre Platte*, which properly describes the shores of Black Bay, is applied loosely by the voyageurs to all this part of the lake shore west of 87°, although not at all appropriate, as it is very rugged.

	° ′	
Variation at 6.30 A.M.	5 44·8	E.
Dip by Gambey No. 1, at 8 A.M. . .	78 53·6	
„ *Fox A gave*	78 46·2	

Total Force	Relative	Absolute	*W.*
By Fox A	1·8535	14·028	(6·0)
„ Lloyd A	1·8506	14·003	(2·5)
	1·8526	14·020	(0·85)

[1] By some mistake, for which I am not responsible, the dip at this station was formerly published as 78° 24′, giving the anomalous and probably impossible force 15·89. The correct value given above is nearly the same as on Otter Island (LVIII), another disturbed locality.

LXV. Observed again at noon, at a place called by the voyageurs *Le Hangar du Diable*, an island off St. Ignace, which I identify with Armour Island of the chart of 1878. It was a very remarkable basaltic island, presenting ranges of regular columns running in a general direction W.*b* N. to E.*b* S. but not perpendicular; their inclination to the N. was from 15° to 40°. I have never seen any mention of this spot, which is seldom passed by travellers. Lat. observed, 48° 45′ 16″; long. 87° 52′.

LXVI. *May* 28.—Observed at the east side of the deep bay (Sheesheep Bay), by *Roche du Bout*, still entered by me as 'The Terre Platte.' Lat. 48° 34′; long. 88° 14′.

		°	′
Variation	7.14 A.M.	0	31·6 E.
„	7.21 „	1	37·6
„	7.25 „	2	11·0
		1	26·7

This anomalous variation shows the powerful local effect of the igneous formations around; the discrepancy between the three results is due to the sluggishness of the compass needle, which only advanced 41′·0 while the sun advanced 2° 20′.

LXVII. On the same day observed at noon near *Point Porphyry*. Lat. 48° 20′ 55″.

LXVIII. Observed again on the west side of a small bay four or five miles east of *Thunder Cape*, or Point Tonnerre. The formation a clay slate. Lat. 48° 20′; long. 88° 52′.

	°	′
Dip, by Gambey No. 1, P.M.	78	23·2
„ *Fox A gave*	78	30

Total Force	Relative	Absolute	*W.*
By Fox A	1·8877	14·287	(6·0)
„ Lloyd A	1·8570	14·055	(2·5)
	1·8786	14·218	(0·85)

The traverse from this point across Thunder Bay is the widest on the lake, being fourteen or fifteen miles. The canoes waited for a calm, and finally reached FORT WILLIAM about midnight.

LXIX. At Fort William, May 29 to 31, 1843, and October 10 and 11, 1844 :—

	°	′	″
Lat. by Captain Kendal, R.N., 1825 . .	48	23	40
,, by my observations, 1843	48	23	25
Long. by the Boundary Commission, 1826 .	89	22	40
,, by Franklin, 1825	89	16	8
,, on Bayfield's chart, 1823 . . .	89	27	30
,, on the revised chart, 1878 . . .	89	13	30

The latter = 5h 56m 54s W., is the longitude here adopted.

	°	′
Variation—Bayfield, 1824, as given by Sabine . . .	9	5·0 E.
Franklin, 1825	7	17·5 E.

By my observations—

	° ′	
1843. May 29, 5.32 P.M. . .	6 14·3 [1]	
,, May 30, 4.12 ,, . .	6 41·9	
,, ,, 4.17 ,, . .	6 56·6	
,, May 31, 9.11 A.M. . .	6 46·1	
		6 34·3 E.
1844. October 11, by collimator . .		5 1·4
Mean		5 47·8

	° ′	
Dip—1843. May 29, Gambey No. 1 . . .	78 9·7	
,, ,, ,, 2 . . .	78 10·2	
		78 10·0
1844. October 11 ,, 1 . . .	78 7·5	
,, ,, ,, 2 . . .	77 55·5	
Repeated ,, 1 . . .	77 55·5 [2]	77 59·5
Mean		78 4·7

Total Force	Relative	Absolute	*W.*
By Fox A May 29 (1) . .	1·8705	14·157	(6·0)
,, ,, (2) . .	1·8653	14·117	(6·0)
,, Lloyd B ,, . .	1·8664 [3]	14·098	(2·0)
	1·8676	14·135	(1·4)

Fox's needle C was observed at Fort William, and the angles taken as base values from Fort Colonge to Norway House.

[1] This result is from two sights only.

[2] On perceiving the discrepancy between needles 1 and 2, the instrument, which had been dismounted, was set up again, and observation repeated. As the value given in 1843 is confirmed by Fox A, which gave the approximate dip 78° 8′·7, I can only attribute the difference in 1844 to a change of the element. In each of the eight positions of needle 1 the readings on the second observation are less than they were in the first.

[3] This depends on the value 1·8730 assigned to Norway House, to which it is referred.

Horizontal force by deflection and vibration :—

	Corrected T s	m	X	ϕ	w
1843. Magnet 30	4·9311 ≛ [1]	0·4550	2·8694	13·993	(1·5)
„ „ 31	5·1537 ≛	0·4196	2·8718	14·004	(1·5)
Mean, 1843				13·998	
1844. Magnet 30	4·3471	0·3962	2·8804	13·942	(1·5)
„ „ 31	4·6387	0·3522	2·8781	13·931	(1·5)
„ „ 17	4·8517	0·6405	2·8618	13·852	(1·5)
Mean, 1844				13·908	(0·75)
Mean, both years				13·945	

Combining these values by weight, the mean is 1·8601 or 14·0785. Sabine (Table XLVIII, 1846) gives two values, the mean of which is 14·015, or, as in his Contribution XIII, 14·01; but he also adopted for the relative force 1·8655, disregarding the absolute results entirely (' Phil. Trans.,' 1846, p. 274), and this was the basis of reduction of Lloyd's needles at forty stations. The relative force, which gives a total force of 14·015, is 1·8517, not 1·865, therefore these values were slightly too great. I have adopted in place of either, as best supported, the value corresponding to 14·0785, viz. 1·8601, with weight 1·55.

June 1, 1843.—I left Fort William at 4·15 a.m., accompanied, as far as the Falls of Kákabeka, by Captain Stacke, of the 71st Regiment, who had been a fellow-passenger from Montreal. No observations could be made this day in consequence of the rain.

Here my connection with the Hudson's Bay Company's canoes was entirely dissevered. The large canoes, called *Canots de maître*, then went on no further than this point; the number and length of the portages precluding their further employment, a lighter canoe, called the *Canot du Nord*, came into use, one of which was appropriated to myself by the directions of Sir George Simpson, with a guide and a supply of provisions, and henceforward I commanded the disposition of my own time, subject only to the necessity of getting on. The following extract from a letter addressed to Lieutenant Younghusband on June 29 explains the matter :—

It was Sir George Simpson's instructions that I should leave the Brigade here and take a canoe to myself, in order not to delay their progress. By so doing time was undoubtedly saved to them, but lost to me, to the amount, I should say, of

[1] ≛ signifies that the bar was vibrated in a stirrup.

one day in four or five, because while with the Brigade cooking and so forth was done for us, and it made no matter if my canoe did not get into camp till eight or nine o'clock, as was usually the case. Now Corporal Henry has to do it all, and I am obliged to give him time enough, not to mention the difference in the rate at which all the movements of a single canoe are made from those of a number in company, they then vie with one another, and work with much more spirit.

LXX. *June* 2.—At the *Portage Ecarté*, or Strayed Portage F, on the old Hudson Bay route, about twenty-six miles from the mouth of the Kaministiquia. It is next beyond the Mountain Portage, lat. 48° 25′ F.; long. 89° 44′.

Dip, Gambey No. 1 . . . . . 77° 13′·5.

This result is nearly 1° too low, but the approximate dip deducible from the angles of deflection with Fox supports it, being 77° 29′·8. It is evidently influenced by local causes.

Total Force	Relative	Absolute	*W.*
Fox A . .	1·8520	14·017	(6·0)
Lloyd A . .	1·8458	13·971	(2·5)
	1·8502	14·013	(0·85)

LXXI. On the same day.—Observed at the *Portage de l'Isle*, probably the Friar's Portage of Franklin, about one mile to the north-east of the last station, lat. 48° 26′; long. 89° 42′, with the following anomalous results:—

	° ′
At 5.39 P.M., variation	39 29·8 E.
„ 5.45 „ „	39 6′·7

Each being the mean of five sights. I can detect no appearance of error in this observation, and the *amount* of local disturbing force indicated is the only thing remarkable; its presence is clearly shown by each of the elements. Thus comparing the adjacent stations we have:

		Dip	Variation	Force
		° ′	° ′	
May 29–30	Fort William	78 10	6 34	1·8673
June 2	Portage Ecarté	77 13·5	—	1·8516 }
„	Portage de l'Isle	—	39 18·2	— }
June 3	Chien Lake	78 26·8	—	1·8650

Subsequent study of the geology of the neighbourhood [1] has shown that the River Kaministiquia at, or very near this locality, is crossed by a band of Laurentian rocks about four miles wide, dividing the

[1] See Prof. Alleine Nicholson, M.D., in the *Quarterly Journal* of the Geological Society, 1873, p. 19.

'copper-bearing' rocks of Lake Superior, which consist of black shales with interstratified traps, from the Huronian district, which includes Chien Lake, and which extends to Lake Shebandowan; a broad dyke of syenite is thrown up between the Laurentian and Huronian formations a mile or two to the east of this portage. Several instances will be pointed out in the course of this survey of the occurrence of great magnetic disturbance at the junction of different geological formations; and as lines of natural drainage are very apt to follow these lines of junction, it follows that the lines of lake or river beds are more likely to present anomaly than an open country. The line of navigation between Norway House and York Factory, and English River, present well-marked examples.

Evidence, however, that all the magnetic elements participate, however much that is to be expected, is not always producible, because the observation for variation was as a rule made at a different place from the observations of dip and force.

LXXII. *January* 3.—At the *Bad* or *Mauvais Portage*. Lat. 48° 29′; long. 89° 44′ F.

Variation, 8.28 A.M. . . . . 5° 48′·0 E.

LXXIII. The same day at the south-west end of the long *Chien*, or *Dog Portage*. The poles of the dipping needle were not reversed, the magnets having been by mistake carried over the portage, but the mean readings, direct and reversed, were at this time nearly identical. Lat. 48° 39′; long. 89° 30′.

	°	′
Dip about 4.30 P.M.	78	26·8
,, by Fox A	78	25·0

Total Force	Relative	Absolute	*W.*
Fox A . .	1·8679	14·137	(6·0)
Lloyd A . .	1·8567	14·053	(2·5)
	1·8646	14·112	(0·85)

Relative horizontal force, October 9, 1844:—

	Corrected T s	*m*	*X*	*φ*	*W.*
Magnet No. 30	4·3888	0·3964	2·8266	14·113	(1·0)
,, ,, 31	4·6840	0·3510	2·8377	14·168	(1·0)
,, ,, 17	4·8717	0·6411	2·8440	14·200	(1·0)
			2·8361	14·160	(0·3)

The mean according to weight is 14·124. This station was the nearest approach on the south side to the assigned position of maximum intensity, being just within the closed oval of 14·19, as laid down by combination of all the observations.

LXXIV. *June* 4.—Observed on *Chien* or *Dog Lake,* about 708 feet above Lake Superior and 347 feet above Little Dog Lake (Dawson). Lat. 48° 44′; long. 89° 40′.

Variation, 9.16 A.M. . . . . . 6° 51′·1 E.

LXXV. On the same day, observed at noon, being still on Chien Lake. Lat. 48° 51′ 16″. About twenty miles beyond Chien Lake, and after passing Jourdan's Portage occurs what is called by Franklin 'Viscous Lake,' the water of which is believed by the voyageurs to oppose extraordinary resistance to a canoe. I myself took a paddle, and found the fact very perceptible; but the cause was no doubt a tacit agreement of the men to relax their own efforts. The water is pure and tasteless, but I had no means of ascertaining its density.

LXXVI. *June* 5.—Observed at a small lake on the height of land at the first 'set down' above the hill, in the *Prairie Portage,* which is thirty miles from Chien Portage, and marks the height of land, 887 feet above Lake Superior (Dawson). It is 2 miles 5 chains long. Lat. 48° 57′·5 F.; long. 90° 1′·5 F.

	°	′
Dip about noon	78	26·1
„ by Fox	78	28·2

Total Force	Relative	Absolute	W.
Fox A . .	1·8586	14·068	(6·0)
Lloyd A . .	1·8471	13·980	(2·5)
	1·8568	14·041	(0·85)

I observed again at this station on my return, October 7, 1844.

Horizontal force by vibrations only:—

		Corrected T s	m	X	φ	W.
By Magnet	30	4·0838	0·3964	2·8327	14·130	(1·0)
„	31	4·6720	0·3510	2·8387	14·227	(1·0)
„	17	4·8705	0·6412	2·8314	14·190	(1·0)
				2·8342	14·182	(0·3)

Combining the two results the mean is 14·086.

LXXVII. Obtained an observation at noon at the *Burnt Portage* between the Prairie and Savannah portages. Lat. 48° 57′ 18″.

October 7, 1844.

LXXVIII. *June* 6.—Observed at the upper or south-west end of the *Savannah Portage*. Lat. 48° 53′; long. 90° 3′ 15″ F. This portage is 1 mile 41 chains long.

Variation, 7.52 A.M.	8° 6′·3 E.

Also at the same place, October 6, 1844 :—

Variation, 7.12 P.M. by azimuths of Jupiter	7°	23′·1 E.
And at 7.50 A.M. October 7 by azimuth of the sun	7	25·6 E.
Mean	7	38·3

Palliser found 6° 53′ E. in this portage in 1857.

	°	′
Dip, 11 A.M.	78	21·8
„ Fox gave	78	14·4

Total Force	Relative	Absolute	W.
Fox A.	1·8647	14·113	(6·0)
Lloyd A	1·8623	14·095	(2·5)
	1·8648	14·107	

June 7.—On the Lake of the Thousand Islands, observation prevented by heavy rain.

LXXIX. Encamped on *Barrel Lake*, about three miles west of the portage, and observed latitude by Polaris, 48° 47′ 37″ (*October* 5, 1844).

LXXX. *June* 8.—Observed at the west end of the *French Portage*. Lat. 48° 35′; long. 91° 8′·4. This portage is 1 mile 60 chains long.

	°	′
Dip, about noon	78	20·4
„ Fox gave	78	5·5

Total Force	Relative	Absolute	W.
Fox A	1·8609	14·084	(6 0)
Lloyd A	1·8544	14·035	(2·5)
	1·8590	14·069	(0·85)

LXXXI. *June* 9.—Observed at the *Portage des Morts*, eleven miles from the last. It is 26 chains long. Lat. 48° 36′; long. 91° 25′·1 F.

Variation by 3 sights only (9.15 A.M.). .	10° 39′·5 E.

LXXXII. Same day.—Repeated the observation at the east end of the *Portage* of the *Two Rivers* (26 chains), about 2½ miles distant W.S.W. Lat., by an observation at noon, 48° 34′ 59″; long. 91° 23′.

Variation, 9.56 A.M.	10° 57′·6 E.

At the same place :—

	°	′
Dip by Gambey	77	49·4
„ Fox gave	77	53·2

Total Force	Relative	Absolute	W.
Fox A	1·8650	14·115	(6·0)
Lloyd A	1·8549	14·039	(2·5)
	1·8612	14·093	(0·85)

At the same place, *October* 4, 1844. Horizontal force in absolute measure by vibration only :—

	Corrected T s.	m	X	φ	W.
By Magnet 30	4·3170	0·3965	2·9206	13·846	(1·0)
„ „ 31	4·6034	0·3510	2·9380	13·929	(1·0)
„ „ 17	4·7976	0·6413	2·9315	13·896	(1·0)
			2·9300	13·890	(0·3)

Combining these two results by weight, the mean is 14·031.

LXXXIII. *June* 10.—Observed at the east end of *Lake à la Crosse*. Lat. 48° 24′; long. 92° 4′.

	°	′
Variation, 7.44 A.M.	7	52·5 E.
Dip, 10 A.M.	77	51·0

Total Force	Relative	Absolute	W.
Fox A	1·8592	14·072	(6·0)
Lloyd B	1·8550	14·040	(2·5)
	1·8580	14·063	(0·85)

LXXXIV. The same day.—Observed at noon on the lake. Lat. 48° 21′ 38″.

LXXXV. *June* 11.—I was detained nearly the whole of this day at the second portage, leading out of Cross Lake, in consequence of having to send the canoe back with my assistant to last night's encampment, to recover something left behind. The place of observation was on a rising ground, towards the West end. Lat., by observation, 48° 14′ 13″; long. 92° 25′.

	°	′
Variation, 7.41 A.M.	10	40·3 E.
„ 8.13 A.M.	10	1·0
Dip by Gambey	77	40·1

Total Force	Relative	Absolute	W.
Fox A	1·8549	14·039	(6·0)
Lloyd A	1·8493	13·996	(2·5)
	1·8532	14·026	(0·85)

LXXXVI. *June* 12.—Observed at noon, on one of the many small islands in *Sturgeon Lake*. Lat. 48° 26′ 29″.

LXXXVII. On the same day.—Observed on another sma. granite island, towards the west end of the same lake, the first portage out of it being about two miles distant, bearing W.N.W. Lat. 48° 27′·5 ; long. 92° 38′.

Dip, 1 P.M. . . . . 77° 44′·8

Total Force	Relative	Absolute	W.
Fox A	1·8633	14·103	(6·0)
Lloyd A	1·8517	14·015	(2·5)
	1·8599	14·077	(0·85)

LXXXVIII. On the same day.—Obtained a couple of azimuths of the sun at the further or north end of the first portage. Lat. 48° 28′ ; long. 92° 41′.

Variation, 3.55 P.M. . . . . . . 10° 25′·2 E.

LXXXIX. *June* 13.—Observed on a granite island on the South side of *Lac la Pluie*, or *Rainy Lake*, about fifteen miles from the entrance, where I was detained some time by the weather. Lat. by observation at noon, 48° 33′ 26″ ; long. 92° 50′.

	°	′
Variation, 9.30 A.M.	10	53·6 E.
Dip by Gambey	77	47·9
„ Fox A gave	77	28·7

Total Force	Relative	Absolute	W.
Fox A	1·8633	14·130	(2)
Lloyd A	1·8514	14·012	(1)
	1·8597	14·095	

The same day reached Fort Frances.

XC. *June* 14.—At Fort Frances, the Hudson's Bay House near the outlet of the lake, and immediately above the Rapids. It is now Alberton.

	°	′	″	h.	m.	s.
Latitude by Franklin, 1825	48	36	18			
By my observation, 1843	48	36	51			
Longitude, Franklin	93	28	33 = 6	13	55·2	
By six sets of lunar distances	93	22	16			
By modern Dominion maps	93	23	0			
By the map of the Boundary Commission of 1826	93	33·2				

The mean, viz. 93° 26′·7, is probably very near the truth.

	°	′	″		
Variation by Franklin, May 28, 1825 . .	10	42	33 E.		
Variation, June 14, 6.25 P.M.	10	33·3 E.			
„ „ 6.52 P.M.	10	36·7		10°	34′·4

Again, *September* 30, 1844, by collimator:—

	°	′	°	′
At 9.26 A.M.	8	36·7 E.		
„ 3.17 P.M.	8	34·1	8	35·4 E.
Mean adopted			9	35
Palliser found in 1857			9	31 E.
Dip, June 14, 1843, Gambey 1 . .	77	28·0 L.		
„ „ Fox A gave . .	77	22·8		
September 20, 1844, Gambey 1 . .	77	41·4 H.		
„ „ „ 2 . .	77	44·5 H.		

The last two observations were made by Corporal Henry, and I am obliged to conclude that there is something wrong about them, as the vibrations show nothing unusual, and the determination of 1843 is supported by an observation by Dr. Rae in 1845, when he found the dip 77° 32′. I assume the dip in 1844, for deduction of force, as 77° 30′. The most simple supposition is that the instrument in 1844 was not in the meridian.

	Total Force	Relative	Absolute	W.
June 14, 1843.	Fox A .	1·8532	14·026	(6·0)
	Lloyd A .	1·8527	14·055	(2·5)
	„ B .	1·8396	13·923	(2·5)
		1·8499	14·009	(1·05)

Horizontal force in absolute measure by vibration and deflection:—

		Corrected T s.	m	X	φ	W.
June 14, 1843.	Magnet 30	4·7821	0·4554	3·0478	14·035	(1·5)
	„ 31	5·0102	0·4179	3·0492	14·042	(1·5)
				3·0485	14·037	
Sept. 29, 1844.	Magnet 30	4·2395	0·3962	3·0306	14·002	(1·5)
	„ 31	4·5242	0·3506	3·0446	14·069	(1·5)
	„ 17	4·7110	0·6401	3·0459	14·072	(1·5)
				30·404	14·047	(0·75)

Mean of both years according to weight, 1·8528, or 14·023.

XCI. *June* 16.—On *Rainy River*, North side, in what is now Township XXIII of Kewaydin. Lat. 48° 41′; long. 94° 31′.

	°	′
Variation, 7.48 A.M.	13	4·5
Dip, 9.0 A.M.	77	57·4
Fox gave	78	14·9

Total Force	Relative	Absolute	W.
Fox A	1·8891	14·298	(6·0)
Lloyd A	1·9006	14·385	(2·5)
„ B	1·8840	14·260	(2·5)
	1·8880	14·309	(1·1)

This force is considerably in excess; the dip is also greater than would be inferred from the adjacent stations: both results point to local disturbance. The station is near the junction of Huronian schists with granitoid gneiss (Dr. Bell's 'Geological Reports,' 1872-3), a condition usually attended with magnetic irregularity (see LXXI).

XCII. On the same day observed at noon on the present Indian Reserve in Rainy River, near the Point aux Pins. Lat. 48° 47′ 29″.[1]

XCIII. On the same day observed at the encampment for the night, probably on *Big Island* in the *Lake of the Woods.* Lat. by Polaris 49° 4′ 36″; long. 94° 43′.

My remaining barometer was broken by accident this day. It had been so placed in the canoe that the cistern end projected a little, unobserved, beyond the gunwale, and on approaching the shore it came violently in contact with the overhanging stem of a tree.

XCIV. *June* 17.—Observed on another island in the lake. Lat. by account 49° 19′; long. 94° 40′. It was probably Falcon Island, or the larger island not named on the map, to the east of it.

	°	′
Variation, 7.58 A.M.	13	42·6 E.
Dip by Gambey, 9.20 A.M.	78	3·7
„ Fox gave	78	1·7

Total Force	Relative	Absolute	W.
Fox A	1·8670	14·131	(6·0)
Lloyd A	1·8576	14·059	(2·5)
	1·8642	14·110	(0·85)

[1] A chart of Rainy River was filed at the Foreign Office October 23, 1826, being part of a survey made under the VIIth Article of the Treaty of Ghent. It is on a very large scale, and inserts seven small streams falling into this river on one or either side:—

	In longitude ° ′	
Riskarko, or Kiskarke Sepi	94 30	north
Rapid River	94 33	south
Steep Bank River	94 39	north
River Baudette	94 41·5	south
Crooked Pine River	94 44·7	north
Winter Road River	94 45·9	south
(No name)	94 47·0	north

Point aux Pins is placed in lat. 48° 49′; long. 94° 47′·2.

The formation was granite and mica slate, containing garnets in abundance.

XCV. *June* 18.—My Iroquois guide, Laurent Tewakewassin, got completely bewildered this day among the archipelago of small low-wooded islands, all singularly alike, which fills the centre of the Lake of the Woods. There was no persuading him for a long time to follow my compass in the absence of the sun, and to keep a northerly course. We lost two days in paddling vainly backwards and forwards, looking for some landmark that he could recognise.

I observed for time and longitude at the breakfast hall 7.33 A.M., but find no observation for variation. Lat. by account, with an estimation of courses to noon, 48° 25′; long. 94° 21′.

XCVI. On the same day observed at noon. Lat. 49° 28′ 7″.

XCVII. On the same day observed again on an island lying to the west of the proper channel; estimated lat. 49° 25′; long. 94° 3′.

	°	′
Variation, 3.14 P.M.	12	26 E.
Dip by Gambey, 1 P.M.	78	16·7
„ Fox gave	78	15·2

Total Force	Relative	Absolute	W.
Fox A	1·8635	14·104	(6·0)
Lloyd A	1·8418	13·908	(2·5)
	1·8571	14·044	(0·85)

A very violent thunderstorm occurred this evening. The sky wore a very threatening aspect about 6.30, and as the guide had lost his way, and was wandering without an object, I decided to encamp. We had hardly done so, when a tremendous storm burst upon us, one which must have sent the canoe to the bottom if we had been caught in the open. It presented an unusual feature, which induces me to copy my note of it.

'The storm commenced about 7 P.M., preceded by lightning. The electric discharges were seen four times undoubtedly striking from the earth upwards, of a strange livid green. Wind sudden, very violent, the rain terrific, a burst apparently following each flash. A few minutes before 8^h, just as the sun was setting, appeared a most brilliant rainbow arch, rising to 40°.'

The same phenomenon of electric discharge from the earth was observed in the Gulf of St. Lawrence August 28, 1842. 'I noticed two or three flashes dart upward from the sea horizon perpendicularly and decidedly' (MS. log).

XCVIII. *June* 19.—Still engaged in searching for the Rat Portage. I observed for time and longitude at 7.46 A.M. Lat. by estimation, 49° 30′; long. 94° 45′.

XCIX. On the same day observed at noon. Lat. 49° 30′ 43″.

C. *June* 20.—Reached at last the Rat Portage (now Kewaydin), at the outlet of the Lake of Woods, at about 8 A.M. Lat. by Tiarks 49° 45′ 56″; by my observation at noon, 49° 46′ 27″; long. 94° 33′ 19″.[1]

	°	′
Variation, 10.11 A.M.	9	38·0 E.
Dip by Gambey	78	7·5
„ Fox A gave	78	7·1
„ „ C „	78	0·5

Total Force	Relative	Absolute	W.
Fox A . .	1·8566	14·053	(6·0)
„ C . .	1·8519	14·016	(4·0)
	1·8547	14·038	(1·0)

Lloyd A (not completed).

The Gambey Dip circle was unfortunately thrown down while my attention was engaged in taking the meridian altitude of the sun, and rendered for the time unserviceable by the breakage of the glasses. It was subsequently repaired at the Red River settlement; but Lloyd's needle A, which was on it at the moment, was ruined.

At the same station, September 25, 1844, I observed the Horizontal force in absolute measure by vibration only.

[1] We have here a good example of the uncertainty attaching to the longitudes of well-known places to which the telegraph is not yet extended. Franklin did not observe at the Rat Portage, but by measurement on his map he places it in 94° 29′. Dr. Tiarks, in determining the longitude of the north-west angle of the Lake of the Woods for the Commissioners under the Treaty of Ghent in 1825, assumed its longitude to be 94° 39′, and the longitude long accepted for that important international landmark (95° 14′ 38″) was entirely based upon this assumption; * he merely determined, with great care, the chronometric difference. I have been unable to find any authority for the longitude 94° 39′; but Dr. Tiarks refers to a map of the Lake of the Woods by Mr. Thompson 'from his surveys'—Thompson is, therefore, probably the authority he followed. But the International Boundary Commission of 1872–6 differs nearly six minutes from Tiarks, placing the north-west angle in 95° 8′ 56″·7, and applying Tiarks' difference, the Rat Portage is in 94° 33′ 18″·7, as given above. The large map compiled at the Topographical Depôt of the War Office, 1870, from Messrs. Dawson and Napier's maps, places it in 94° 33′.

The Dominion map of Kewaydin, dated 1876, in 94° 31′. My chronometer observations, which, however, were not favourable, the sun's hour angle being too small, made it 94° 41′ 10″.

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* *See* his affidavit sworn in New York, November 18, 1825. *American Journal of Science*, vol. xv.

	Corrected T s.	m	Relative	ϕ	W.
By Magnet No. 30	4·3592	0·3965	2·8641	13·918	(1·0)
„ „ 31	4·6466	0·3515	2·8795	13·993	(1·0)
„ „ 17	4·8392	0·6423	2·8768	13·981	(1·0)
			2·8734	13·964	(0·3)

The mean for both years is 1·8449, or 14·023.

June 21.—Left the Rat Portage at 2.30 A.M., reached the Grande Décharge (Discharge of Charette's Little Rock F) at 5.25 A.M., and the White Earth Portage at 8 A.M.

CI. Observed at noon on the Winnipeg River. Lat. 50° 9′ 7″.

CII. About half an hour afterwards I landed on the east or left bank of the river, at an expansion of the stream amounting almost to a small lake, but without a name, to observe the Göttingen Term-day. Latitude by account 50° 10′·2; longitude 95° 12′. The instruments were erected and adjusted in the course of a couple of hours. The Term-day observations were commenced at 3^h 2^m 40^s of mean time, corresponding to 10^h 3^m 6^s of Göttingen mean time, and continued to the same hour of the day following. The weather was perfectly calm, the stillness unbroken except by the frequent cry, half wail, half shriek, of a loon in the neighbouring water. No decided magnetic disturbance occurred excepting a marked movement of declination between 9.47 and 10.14 A.M. (22^d 4^h 48^m to 22^d 5^h 15^m Göttingen), which appears to have been local, for there was no trace of it at Toronto, distant about 900 miles. There was a movement of Horizontal force at the same time (*see* p. 12).

At this station I observed also:—

	°	′
Variation at 5.12 P.M.	12	28·7 E.
Dip with the Fox Circle, Needle A . .	79	10·0
„ „ „ „ B . .	79	11·3

Total Force	Relative	Absolute	W.
Fox A . . .	1·8767	14·204	(6·0)

The dip as well as the force at this station would appear to indicate a high degree of local disturbance, on which account it was omitted by Sir E. Sabine from his map. The former rests on two observations by two observers: Needle A by Corporal Henry, needle B by myself, the original entries of which I have re-examined. The exceptional force is confirmed by two sets of deflections with bar. 30, giving X = 2·9289; but with the dip recorded this gives ϕ = 15·597. There is, therefore, something wrong with the dip.

June 22.—I quitted the station of Term observation at 3.45 P.M., and reached the Island Portage, or Portage de l'Isle (2) at 4.25, where we encamped.

June 23.—Left the camp at 3.30 A.M.; Jacob's Portage 5.0 to 5.40; the first Woody Point Portage 7.10 to 8.45 A.M.

CIII. Encamped on the Burnt Wood Portage, which comes between the two Woody Point Portages. Observed. Lat. by Polaris 50° 19′ 10″; long. 95° 36′.

September 22, 1844.

CIV. *June* 23, 1843 (*resumed*).—Reached *Slave Falls* and *Portage* 11 A.M. and remained to 2 P.M. Lat. by observation 50° 14′ 41″; long. 95° 40′.

	°	′
Dip by Fox's needle A	78	57·1
The intensity observations gave . . .	78	56·0

Total Force	Relative	Absolute
Fox A	1·8621	14·094

The latitude of this station is nearly 4′ more to the S. by Franklin's route, but he appears to have obtained no observation on the day he passed this portage (June 4).

CV. On the same day reached *Barrier Portage*. Lat. by account 50° 11′; long. 95° 43′.

CVI. *June* 24.—Left camp at 3.15 A.M., taking the route by the *Pinawa River*, a small channel only navigable when the waters are high, which cuts off the 'Seven Portages' of the Winnipeg River, and leads into Cap Lake or Lake Bonnet.

Observed at a portage in this channel. Lat. by account 50° 16′; long. 96° 3′.

Variation, 7.26 A.M. . . . 12° 48′·6 E.

Professor Hind noticed in 1857 an unusual amount of local attraction at an island of gneiss in Lake Bonnet, which we entered soon after. 'The needle here refused to act, and on passing close to a high exposure of the schist it vibrated between 50° W. and 50° E. of north as roughly estimated' (Report, p. 294). The above variation is irregular, in defect, and also indicates local disturbance.

CVII. On the same day, observed at noon on *Lake Bonnet* or *Çap Lake*. Lat. 50° 20′ 56″.

This was a day of incessant unloading and reloading the canoe at different short portages, and no other magnetic observations were taken. Encamped at 9.30 P.M.

CVIII. *June* 25.—Left camp at 3.45 A.M. and reached FORT ALEXANDER, about $1\frac{3}{4}$ mile from the mouth of the River Winnipeg.

	°	′	″
Latitude by Franklin, 1825	50	36	39
By my observations, 1843.	50	37	3
Longitude by Franklin	96	21	25 W.
By my observations, referred to Fort Garry as a standard meridian	96	23	13 W.
Variation, Franklin, June 5, 1825	15	15·7 E.	
My observations, June 25, 6.37 P.M.	13	29·0 E.	
„ June 26, 4.49 A.M.	14	25·3	

Again, *September* 20, 1844 :—

	°	′
By Collimator Magnet, 7.39 A.M.	14	3·4 E.
„ „ 8.26 A.M.	14	4·2
Mean	14	0·4

The first reading, on June 25, which I have rejected for its irregularity, gives, taken singly, 15° 31′·2, and if we include it, the mean of the set becomes 13° 29′; in either case it is irregular, but I see nothing to justify the rejection of the observation.

	°	′
Dip, Franklin, June 5, 1825	78	47·1
My observation with the Fox circle, needle A, with deflectors with weights, June 25, 1843	78	51·8
With the Gambey circle	78	55·8
September 30, 1844, No. 1	79	3·4
„ „ „ „ 2	79	2·5

I adopt the mean 78° 58′·4.

	Total Force	Relative	Absolute	W.
June 25.	Fox A.	1·8559	14·047	(6·0)

Horizontal force in absolute measure, *September* 19, 1844 :—

	Corrected T s	m	X	φ	W.
Magnet 30	4·4898	0·3962	2·7019	14·229	(1·5)
„ 31	4·7943	0·3515	2·7044	14·237	(1·5)
„ 17	5·0090	0·6414	2·6888	14·156	(1·5)
			2·6984	14·207	(0·45)
Mean				14·098	(0·9)

SECTION III.

FORT ALEXANDER TO YORK FACTORY ON HUDSON'S BAY.

About 695 geographical miles.

CIX. *June* 26, 1843.—Left Fort Alexander. Observed at noon. Lat. 50° 38′ 33″.

CX. Observed at the encampment on Lake Winnipeg (= muddy water) a little way round the point. Lat. by account, 50° 35′; long. 96° 35′ 38″.

	°	′
Variation, 6.6 P.M.	13	41·0 E.
Dip by the Fox circle, 7 P.M.	78	34·4

Total Force	Relative	Absolute
Fox A	1·8667	14·128

Out of six customary deflections of the Fox needle, one was, on this occasion, omitted, in consequence of the failure of daylight at 8 P.M.

CXI. *June* 27.—On *Lake Winnipeg*, very near the last station. By observation at noon. Lat. 50° 33′ 25″; long. 96° 36′.

Dip by the Fox circle . . . . . 79° 5′·1

This was a day of detention. 'The wind blew steadily, and raised a sea which the canoe could not face.' It is to be regretted that the variation and force were not observed, as the dip is anomalous. It would seem that the weather prevented observation.

CXII. *June* 28.—Left camp at 3.45 A.M. Reached the mouth of the Red River about 8 A.M. Observed at noon, about ten miles below the 'Stone Fort.' Lat. 50° 16′ 20″.

Reached Lower Fort Garry, or 'The Stone Fort,' between 4 and 5 P.M., where I had the pleasure of finding the Governor of the Hudson's Bay Company, Sir George Simpson.

CXIII. *June* 29.—Accompanied Sir George Simpson to Upper Fort Garry, or Fort Assiniboia, now Winnipeg City, a distance of twenty miles by land from the Lower Fort, and near the junction of the Assiniboine and Red rivers, sometimes called the Forks. Here I remained until July 4; detained by necessary repairs to the dip circle, and other requirements.

Upper Fort Garry.

	°	′	″
Latitude by Polaris, June 29, 11.16 P.M.	49	54	10
" " " 11.36 P.M.	49	54	26
" by circum-meridian alts. of the sun, June 30	49	53	10

The latter is adopted.

Fort Garry is laid down in Arrowsmith's map of British North America, dated April 25, 1844, in longitude 97° 6′, as nearly as the small scale of the map admits of measurement. Upon grounds which I cannot at present remember, or trace, I assigned 97° 3′. It appears, however, to be 12′·6 more to the westward. I am indebted to Major Sanderson, R.E., of the British American Boundary Commission of 1872–6, for the information that the true longitude of the Fort is 97° 15′ 36″, or 6^h 29^m 24^s W., made out as follows. The longitude of Pembina was determined by that Commission to be 97° 13′ 51″·5, whence that of the 'First Principal Meridian' of the Dominion Government surveys of Manitoba and the North-West Territory is 97° 27′ 9″. Fort Garry is, by the surveys, 8·75 statute miles east of this 'First Principal Meridian,' equivalent to 11′ 33″ of longitude. The adoption of this datum has rendered it necessary to correct the longitudes on Lake Winnipeg.

	°	′
Variation by compass, June 29, 5.11 P.M.	15	27·6 E.
" " " 30, 7.18 P.M.	16	42·1
Mean	16	4·8

	°	′
Dip, July 3, Gambey needle No. 1	78	19·4
" " " " 2	78	16·3
Mean adopted	78	18·8

	°	′
June 29, Fox circle, needle A gave	78	17·0
" " " C "	78	10·0
July 3 " " A "	78	10·7
This result is disregarded	78	12·6

Total Force	Relative	Absolute	W.
Fox A.	1·8619	14·092	(6·0)
„ (2)	1·8605	14·081	(6·0)
„ C	1·8529	14·024	(4·0)
„ „	1·8525	14·021	(4·0)
Lloyd A	1 8516	14·014	(2·5)
„ B	1·8584	14·066	(2·5)
	1·8572	14·056	(2·5)

Horizontal force in absolute measure by deflection and vibration:—

	Corrected T s.	m	X	φ	W.
By Magnet No. 1, June 30	4·9748	0·4502	2·8488	14·005	(1·5)
„ „ „ 31	5·1938	0·4161	2·8495	14·008	(1·5)
			2·8491	14·006	(0·3)

Mean allowing to the respective results the weights of 2·5 and 0·3 is 14·056.

CXIV. *July* 4.—Left the Fort and encamped about six miles from the mouth of *Red River*. Lat. by Polaris 50° 18′ 12″; long. 96° 52′.

Dip, 8 P.M., Gambey No. 1 . . . . . . 78° 34′

Total Force	Relative	Absolute	W.
Fox A.	1·8603	14·080	(6·0)
Lloyd B	1·8667	14·129	(2·5)
	1·8621	14·094	(0·85)

CXV. *July* 5.—Left camp 2.30 A.M., reached the mouth of the Red River 4.30. Observed at noon on the west side of the lake from the lake horizon. Lat. 50° 43′ 51″.

CXVI. Encamped on the same side, on a sandy beach covered with fragments of limestone, with a swamp in rear. The musquitoes here were almost intolerable. It was necessary to fill the tent with acrid smoke from damp weeds to obtain a moment's respite. Lat. by account 51° 36′; long. 96° 56′. The south point of Ox Head bore E.N.E. from this camp.

	°	′
Variation, 6.53 P.M., one sight	13	40·9 E.
„ 7.5 P.M., two sights	13	10·5
„ 7.19 P.M., four „	14	4·2
Mean	13	45·5
Dip, Gambey No. 1, 8 P.M.	79	11·8
Fox, needle A, gave	79	1·2

Total Force	Relative	Absolute	W.
Fox A	1·8596	14·075	(6·0)
Lloyd B.	1·8665	14·127	(2·5)
	1·8617	14·090	(0·85)

July 6.—After passing Big Grindstone Point I coasted the east

side of the lake, on which side all my observations were made on the return voyage in 1844. I take the stations in their order from Fort Alexander northwards.

CXVII. Landed at a point about eleven miles S.S.E. from the south end of 'Ox Island,' which is probably the same as 'Big Island' on Dr. Bell's map of 1878. Franklin marks 'Ox Head' on the mainland, Dr. Bell applies the term to the point of this island. By observation at noon. Lat. 51° 4′ 0″; long. 96° 26′.

Dip, A.M. . . . . 79° 31′·5

Horizontal force in absolute measure by vibration only :—

	Corrected T s	*m*	*X*	*φ*	*W*.
By Magnet 30	4·5414	0·3970	2·6362	14·499	(1·0)
,, 31	4·8576	0·3512	2·6370	14·505	(1·0)
,, 17	5·0498	0·6418	2·6462	14·543	(1·0)
			2·6398	14·516	

This force is excessive.

September 18, 1844.

CXVIII. Observed at an island, probably the one cut off by Loon's Straight in Dr. Bell's map. Lat. by Polaris the previous evening 51° 34′ 0″; long. 96° 43′.

Variation by collimator, 9.36 A.M. . . . . 15° 6′·7
Dip . . . . 79 6·1

Horizontal force in absolute measure by vibration only :—

Total Force	Corrected T s	*m*	*X*	*φ*	*W*.
By Magnet 30	4·4662	0·3970	2·7254	14·415	(1·0)
,, 31	4·7866	0·3512	2·7158	14·365	(1·0)
,, 17	4·9768	0·6418	2·7221	14·398	(1·0)
			2·7211	14·393	(0·3)

Here, too, the force is excessive.

September 17, 1844.

CXIX. *July* 6, 1843 (*resumed*).—Observed at the camp, nearly opposite the Bull's Head. A straight, about three miles wide and twelve miles long, here divides Lake Winnipeg into a northern and a southern basin, and is the point of junction of the limestone of the west side with the eruptive formations, consisting of Syenitic gneiss, granite, and greenstone on the east side. Here, as may be expected, are evidences of considerable local disturbance in the magnetic elements, which also appear at the next two stations. Lat. by Polaris 51° 36′ 42″; long. 96° 53′.

		°	′
Variation by compass, 7.59 A.M.	. . .	16	25·1 E.
Dip, Gambey No. 1, 6.30 P.M.	. . .	79	38·0

Total Force	Relative		Absolute	W.
Fox A . .	1·9085	H	14·445	(6·0)
Lloyd B . .	1·9161	L	14·502	(2·5)
	1·9607		14·462	(0·85)

Franklin found the variation in 1825 14° 46′ E. within a mile or two of this station. There is a puzzling discrepancy between my dip and the dip deducible from the angles of deflection of Fox's needle, which is only 78° 11′. Such discordance between results obtained within a few yards of each other is not without precedent, but the case is extreme, and further observations in the same locality are desirable.[1]

CXX. Observed at noon. Lat. 51° 41′ 55″.

September 16, 1844.

CXXI. In the forenoon of the same day observed at a spot 3½ miles N.W. from the last, nearly opposite the Tête du Chien. Lat. by account, 51° 44·5′; long. 97° 2′. Formation, gneiss.

		°	′
Variation by collimator, 9.5 A.M.	. . .	15	24·2 E.
Dip by Gambey	. . . .	79	39·0 E.

Horizontal force in absolute measure by vibrations only :—

	Corrected T	m	X	ϕ	W.
	s				
By Magnet 30	4·4437	0·3971	2·7564	15·342	(1·0)
,, 31	4·7457	0·3512	2·7630	15·379	(1·0)
,, 17	4·9326	0·6418	2·7710	15·424	(1·0)
			2·7634	15·382	(0·3)

The force indicates great disturbance.

September 16, 1884.

[1] Each observation for dip is full, complete, and consistent with itself. There are no grounds for preferring one to the other. The instruments were generally set up some twenty or thirty yards apart ; there is no record of the actual distance between them, but I can only conclude that the Fox circle, which is the one in doubt, was under some strong influence, exerted close at hand.

The details are :—

		°	′
Dip from deflections with 2·5 grains	. . .	78	10·2
,, ,, 3·0 ,,	. . .	78	12·9
,, ,, 3·5 ,,	. . .	78	5·5
,, ,, 4·0 ,,	. . .	78	14·5
Mean	. . . . . .	78	10·8

At the next station agreement is re-established. See, for a similar excess of force, Little Rock Portage on August 31, Station CXCV, and Cape Gargantua, Station LII.

CXXII. *July* 7, 1843.—Opposite the Dog's Head. Lat. by account, 51° 40′; long. 96° 56′.

		°	′
Variation by compass, 7.36 A.M.	. .	21	37·1 E.
„ „ 7.45 „	. .	21	39·5

This is confirmatory evidence of much local disturbance in this neighbourhood. Each result is from the mean of six observed azimuths.

CXXIII. Quitting the last station at 7.50 A.M. I observed at noon, lat. 51° 45′ 8″, and was forced by the wind to land about half an hour later upon a small island, without a name, where we were detained until 5 P.M.

CXXIV. Nameless Island, E. of Bear Island. Lat. by account, 51° 46′; long. 97° 0′.

	°	′
Dip by Gambey 1, 1 P.M.	79	28·3
„ Fox A	79	28·8
„ „ C	79	32·2

Total Force	Relative	Absolute	W.
By Fox A	1·9020	14·396	(6·0)
„ C	1·9080	14·440	(4·0)
Lloyd B	1·9052	14·420	(2·5)
	1·9045	14·414	(1·25)

CXXV. *July* 7 (*continued*).—On quitting the island there is a wide traverse across a bay (entered by Blood River), which, being made, I encamped near Rabbit Point. Lat. by Polaris, 51° 52′ 37″.

CXXVI. *July* 8.—Left camp 3.15 A.M. Landed for breakfast and observation, 7.30 A.M. Lat. by account, 52° 6′·5; long. 97° 8′.

Variation, 8.5 A.M . . . . 15° 38′·6 E.

CXXVII. Same day.—Observed at noon. Lat. 52° 12′ 18″.

CXXVIII. Observed at a station near *Berens River*, intermediate between two stations of July 8. Lat. by observation at noon, 52° 20′ 56″; long. 97° 10′.

		°	′
Variation by collimator, 3.48 P.M.	. . .	16	54·6 E.
Dip by Gambey	. . . .	80	24·4

Horizontal force in absolute measure by vibration only :—

	Corrected T s	m	X	φ	W.
By Magnet 30	4·7613	0·3971	2·3974	14·385	(1·0)
,, ,, 31	5·2045	0·3512	2·4055	14·434	(1·0)
,, ,, 17	5·2997	0·6429	2·4002	14·369	(1·0)
			2·4010	14·396	

September 14, 1844.

CXXIX. *July* 8, 1843 (*resumed*).—Observed at the place of encampment near the present Wesleyan Mission Station at Berens River. Lat. by Polaris, 52° 22′ 38″; long. 97° 12′.

	°	′
Variation by compass, 6.52 P.M. . .	14	13·3 E.
,, ,, 7.4 ,, . .	14	20·7

I give the first for confirmation, but as it is by one sight only, and the second by seven, I take as the mean 14° 19′·8, which is so irregular as to indicate local disturbance.

	°	′
Dip by Gambey, 7 P.M.	80	39·2
,, Fox A	80	28·9

Total Force	Relative	Absolute	W.
By Fox A	1·8696	14·150	(6·0)
Not observed for want of daylight, Lloyd . .	nil		

CXXX. *July* 9.—Observed about five miles W.N.W. from last night's camp, probably on the southern Mossy Point. Lat. by account, 52° 25′; long. 97° 18′.

Variation, 8.31 A.M. . . . . . 19° 22′·7 E.

I find an allusion to this day in one of my letters, dated July 24, 1843, which also explains my slow progress at this time:—'Lake Winnipeg is treacherous; so shallow that a sea rises in a moment, and full of wide bays, which are so many traps, at which one is constantly detained. The lake is indeed so shallow, that we got aground on Sunday morning, July 9, in the middle of a violent thunderstorm, and were kept all day on a miserable naked sand-bar. My Iroquois *Butte* Laurent had a character at one time for being an adventurous fellow, but he is now rather old for his work, and was always declaring it blew too hard to go on.'

Dr. R. Bell made, at my request, a number of soundings in 1880, finding a general depth of 40 or 50 feet—nowhere more than 16½ fathoms, or under 100 feet.

CXXXI. *July* 10.—Left camp at 4.10 A.M. Observed at the breakfast halt, which must have been near *Leaf River.* Lat. by observation at noon, 52° 31′ 37″; long. 97° 18′.

Variation, 8.3 A.M.		19°	12′·2
		°	′
Dip by Gambey No. 1 gave		80	3·7
„ „	2.3 P.M.	80	7·2
„ Fox A gave		80	8·2

Total Force	Relative	Absolute	*W.*
Fox A (1)	1·8656	14·120	(6·0)
„ (2)	1·8652	14·117	(6·0)
Fox C	1·8721	14·170	(4·0)
Lloyd A	1·8584	14 065	(2·5)
„ B	1·8694	14·149	(2·5)
	1·8646	14·113	(2·1)

This was a day of detention.

CXXXII. Observed near *Poplar Point* on the return voyage. Lat. 52° 56′ 12″.

CXXXIII. *July* 11.—Left at 6 A.M. Observed at noon. Lat. 52° 57′ 50″. No other observations were made.

I am informed by Dr. Bell that the Dominion Lands Department gives the variation a little south of the outlet of Poplar River in 1877, that is to say, two or three miles north of this station, as 15° 20′ E. He observed 15° 15′ in 1879 in the same neighbourhood.

September 13, 1844.

July 12.—Left at 3 A.M. Chronometer No. $\frac{2}{503}$, carried by my assistant, Corporal W. Henry, was reported stopped at 7 A.M. I could obtain no explanation at the time. The watch was left at Norway House for transmission to England, and upon examination the mainspring was found to be broken, evidently the result of some accident not made known to me. The event was the more unfortunate, as if it had run but ten hours further, its mean rate from Fort Garry would have been directly ascertained.

I arrived this evening at NORWAY HOUSE, but there is another station visited later to be first given.

CXXXIV. *August* 12.—On the site of Old Norway House, on *Mossy Point.* Position determined by Franklin in 1819. Lat. 53° 41′ 38″; long. 98° 1′ 24″.

		°	′
Dip by Gambey 1, P.M.	. . . . .	80	45·4
„ Fox, needle C, gave	. . .	80	49·4

Total Force	Relative	Absolute	W.
Fox C . . .	1·8642	14·110	(4·0)
Lloyd A . .	1·8775	14·210	(2·5)
„ B . .	1·8771	14·207	(2·5)
	1·8715	14·162	

CXXXV. Dr. Bell observed the variation about one mile north of Warren's Landing, on this Point, in 1878, 16° 45′ E.

Norway House.

CXXXVI. I visited this station twice in 1843, and again in 1844. The observations are here collected. Lat. by observation, July 14, 53° 59′ 38″; August 8, 53° 59′ 28″. Long. as determined by Mr. Taylor, formerly astronomer to the Hudson's Bay Company, 98° 7′, or 6^h 32^m 28^s west. It is very nearly, if not actually, upon the site of a former Jack House, which is laid down by Franklin about 1′ 20″ west of Old Norway House, of which he found the long. to be 98° 1′ 24″; therefore his position of the present Norway House may be taken to be 98° 2′ 40″.

	°	′	″
By two sets of Lunar distances, moon for Jupiter west of her, I made it	98	19	34
And by two sets moon from sun east of her .	97	44	22
Mean of these four sets . .	98	1	58
The mean of the whole is .	98	3	54
The most recent map places it, by what authority I know not, in	97	55[1]	

				°	′	
Variation, July 13, 1843, 6.14 P.M.			.	13	45·1	E. *rejected.*
„	„	„ 6.45 „	.	16	21·9	
„	„	„ 7.4 „	.	16	0·0	
„	„	„ 7.10 „	.	15	58·6	
„	„	„ 7.30 „	.	15	12·1	
				15	53·1	

The first two observations were made with the compass card upon the pivot used all the way from Canada, which was tipped with some hard metal termed 'natural alloy,' the nature of which

[1] *See* Geological Survey, 1878. My lunars have been examined and reduced by Mr. Coles, R.G.S.

I do not know. The compass was extremely sluggish, and the card only moved 2° 40′ for a motion in azimuth of the sun of 5° 54′.

The card was then removed, and a hard steel point substituted, with which the other three sets were taken. The card now moved 6° 3′ for the same movement through 5° 15′. There are no signs of disturbance at Toronto at this time (Gött., 13h to 15h).

		°	′
Variation by collimator magnet, September 6, 1844,	5.22 P.M.	14	51
,, ,, ,, 7, ,,	9.12 A.M.	15	22
		15	16·5

I take for the station, 15° 35'.

			°	′	°	′
Dip, July 12, 1843, P.M.	Gambey	1	81	11·0	81	8·9
,, 13 ,, ,,	,,	2	81	6·2		
Aug. 9 ,, A.M.	,,	1	81	9·4		
Sept. 7, 1844 ,,	,,	1	81	11·1		
,, ,, ,,	,,	2	81	11·4	81	11·2
					81	10·0

The mean by a great number of observations with Fox's needles is 81° 11′·1.

Total Force.

Norway House being a station of critical importance, and the standard of reference for all the more northern stations, I give in full detail the observations upon which its relation to Toronto is established. The total force at Toronto on the relative scale in use is, as already explained, p. 56, 1·8360. The following were assumed by Sabine to be the mean angles of deflection of Fox's needle A at Toronto in 1843, with the weights specified.

And since the sines of the angles of deflection are as the weights, if these angles are truly in accord, their natural sines divided by the weight should be constant. It will be seen by the figures in the last two columns below that the differences are small. The weight 2·0 grains was only used at four stations, for the other four weights the mean difference is 0·00023, or about 0·0025 on the actual scale of force.

		θ		$\frac{\sin\theta}{W}$	
		°	′		
Th. 46°.	With 2·0 grains . .	21	13·0	0·1809	− ·00077
	,, 2·5 ,, . .	27	2·3	0·1818	+ ·00009
	,, 3·0 ,, . .	33	8·7	0·1822	+ ·00053
	,, 3·5 ,, . .	39	27·0	0·1815	− ·00018
	,, 4·0 ,, . .	46	45·9	0·1820	+ ·00037
				0·18172	

Employing then these angles as the standard of comparison, we obtain from the recorded angles given by the same weights at Norway House in 1843 the following results :—

TABLE XV.

(NEEDLE A.)

Date	Weights employed					Mean, as observed	Temp.	Reduced to 46°	W.
	2·0	2·5	3·0	3·5	4·0 gr.				
1843									
July 13 .	—	1·8585	1·8817	1·8482	1·8743	1·8657	69°·8	1·8728	(6·0)
August 8 .	1·8749	1·8576	1·8549	1·8479	1·8610	1·8592	79·0	1·8690	(6·0)
„ *bis*	1·8543	1·8604	1·8789	1·8471	1·8612	1·8604	81·8	1·8714	(6·0)
„ 9 .	1·8889	1·8455	1·8458	1·8379	1·8434	1·8523	83·8	1·8635	(6·0)
Means .	1·8727	1·8555	1·8653	1·8452	1·8600	1·8594	78·6	1·8692	(2·4)

The same needle (A) was observed again at Norway House in September 1844, and subsequently at Toronto. It was by this time somewhat impaired in condition, but the results are in fair accordance with the above.

Fox's needle C was also observed on August 8, but the axles were rusty. Only two angles gave true results, mean 1·8737, or 14·181.

Observations of 1844, reduced to uniform temperature :—

Weight	Needle A	Needle C
1·5 grain	—	1·8490
2·0 „	—	1·8719
2·5 „	1·8615	1·8578
3·0 „	1·8514	1·8547
3·5 „	1·8502	1·8785
4·0 „	1·8418	—
4·5 „	1·8435	—
As observed . .	1·8497	1·8624
As reduced . .	1·8554	1·8669

The mean of the whole, allowing weight 5 to each result of 1844, is 1·8669 = 14·129 in absolute measure.

This value may be compared with the value deduced from observations of the absolute horizontal force at the same stations.

At Toronto the values established, and forming the common basis of all the reductions are (*ante*, p. 56) :

Total force in relative measure	1·8360
„ „ in absolute measure	13·896

At Norway House we have, by deflection and vibration :—

	Corrected T s.	m	X	φ	W.
1843, July 14, No. 30	5·7609	0·3904	2·1780	14·128	(1·5)
„ „ „ 31	6·1351	0·4400	2·1737	14·126	(1·5)
1844, Sept. 6 „ 30	5·0058	0·3967	2·1734	14·185	(1·5)
„ „ „ 31	5·3569	0·3511	2·1699	14·162	(1·5)
„ „ „ 17	5·5516	. 0·6441	2·1800	14·228	(1·5)
			2·1750	14·1658	(0·75)

These absolute values are in the ratio 1·0194; the direct comparison gives the ratio 1·0166, a satisfactory agreement.

Combining then the mean results by these two independent and dissimilar methods of observation, I obtain for the total force, Norway House, in relative measure, 1·8677, in absolute measure 14·136, being somewhat less than the values formerly assigned, which were respectively 1·873 and 14·18. The observations reduced to Norway House as a base have been corrected accordingly.

I left Norway House on Friday evening, July 14, but made little progress. The guide took a wrong channel, and got among some beaver dams, causing a considerable loss of time. The stations which follow are arranged in geographical order, not in order of date.

CXXXVII. Observed at noon, on the day of my return to Norway House, on *East River*. Lat. 54° 7′ 49″ (*August* 7, 1843).

CXXXVIII. *July* 15.—Left my camp on East or Sea River at 3.15 A.M. A portage, 5.35 to 6.15. Halt, 7.5 to 8.10. Blackwater River, 8.34. Hairy Lake, 11.5 to 11.55. Sea River Portage, 4.0 to 4.10. Carpenter's Lake at 5 P.M.

Observed on Carpenter's Lake, an expanse beyond Sea River Falls. Lat. by account, 54° 14′; long. 97° 40′.

Variation, 7.20 A.M. . . . . . . 21° 26′·0

This is a marked case of local disturbance, and the station was omitted by Sabine. It is probably explained by the change of geological formation. By Dr. Bell's map of 1878 we are here close upon the margin of a narrow irregular basin of Huronian schists, which extends from longitude 98° 10′ to 94° 10′. The line of water communication this day, the 15th, again on August 5, also from P.M. July 17 to A.M. July 20, and from August 2 to 4, lies within this basin. July 17 A.M. and August 4 P.M. it lies a little to the south of it. The boundary is crossed four times between Norway House and York Factory, a circumstance which goes far to explain the apparent anomalies of the observations for variation on this part of the route, which were equally perplexing to Sir John Franklin.

CXXXIX. Observed at *Blackwater Creek*. Lat. by Polaris 54° 18′·8.

August 6, 1843.

CXL. *On the same day* observed on *Hairy Lake* at the mouth of the River Echiamamis. Lat. by account, 54° 20′; long. 97° 28′.

	°	′
Variation, 4 P.M.	18	43·7 [1]
Dip by Gambey, 4.30 P.M.	81	20·9

Total Force	Relative	Absolute	W.
Fox A	1·8590	14·070	(6·0)
Lloyd B	1·8577	14·060	(2·0)
	1·8587	14·067	(0·8)

August 6.

CXLI. *July* 15 (*resumed*).—Observed at the encampment on one of the chain of small lakelets west of the Painted Stone Portage. Lat. by account, 54° 23′; long. 97° 4′.

Variation, 8.2 P.M. . . . . . . 35° 11′·2 E.

I can only leave this result as I find it, for verification by future travellers, like the corresponding case, Station LXXI. There is nothing in the original entry to warrant the rejection of the observation. It was omitted by Sabine.

CXLII. *July* 16.—Observed at another point near the source of the Echiamamis, two or three miles (40 min. in time) from the height of land. Lat. by account, 54° 21′; long. 97° 2′.

Variation, 7.45 A.M. . . . . . 18° 39′·7 E.

The day clouded over, but two detached sights were noted, one before and one after the above set.

	°	′
At 7.37	20	39·8 E.
„ 8.10	20	1·2 E.
Mean of the whole . .	19	5 E.

[1] Several pages of my notebook in August have been entirely obliterated by the leaves having been wetted. I give the observations as formerly published.

CXLIII. I encamped at the *Painted Stone Portage.* Latitude by altitudes of Polaris 54° 22′·3 ;[1] long. 96° 59 (*August* 5, 1843). This evening was marked by a magnificent display of aurora, the most brilliant that I ever witnessed, and the more remarkable, as it must have been very near the earth's surface, as it appeared to be. It was not observed at any of the nearest Hudson Bay posts, or by the travellers in the brigade of canoes then on its way north, which was only a few marches off, or at any station in lower latitudes.[2] I transcribe therefore my account of it given in letters addressed to General Sabine and Lieut. Younghusband a few days afterwards:—

. . . A magnificent aurora from 9 P.M. to near midnight, more brilliantly coloured and more rapid in its movements than anything I have hitherto seen. It began by a small arc, which rapidly extended and became almost fearfully bright as it reached the zenith. It there broke up, wheeling and dancing over the sky in a wonderful manner. Presently appeared over the trees another arch of a bright rose colour, and joined it. There was an appearance of depth about it, not as if it were a passing flash, but as if solid, and every fibre in the most rapid and incessant motion. Heavy curtains of light, variously tinted, seemed at times to be let suddenly down, and as suddenly raised or withdrawn. It was such a spectacle as can never be forgotten.

August 5 was not noticed as a day of magnetical disturbance at any of the stations, but disturbance was recorded on the 3rd, 4th, 7th, and 8th of that month. The nearness of this aurora to the earth, which may be inferred from its not having been seen at other places, is paralleled by another example on September 9, when a display of the first brilliancy was seen at the Methy Portage. I was at Lac à la Crosse, about 100 miles to the south, engaged in observations until late at night, and can affirm that no aurora was visible there, nor is there any display recorded elsewhere for this date.

CXLIV. Observed at the *White Fall Portage*, which appears to be the one called Robinson's Portage by Dr. Bell. Lat. of south end 54° 23′ 20″ F. ; long. 96° 31′ F. Dr. Bell places it about 6′ more to the west.

	°	′
Variation, 3.36 P.M.	17	32 E.
Dip 1 P.M., Gambey 1	81	47·9
„ Fox A	81	51·6

[1] As formerly published, the original entries are illegible.

[2] *Vide* Lovering on the periodicity of the Aurora Borealis, in *Memoirs of the American Academy*, 1868, p. 135.

Total Force	Relative	Absolute	W.
Fox A	1·8790	14·221	(6·0)
Lloyd B	1·8694	14·149	(2·0)
	1·8766	14·203	

August 5.

CXLV. Observed at the upper portage of *Hills Gates*, leading from Windy Lake into Holey, or Oxford Lake. Lat. 54° 42′; long. 96° 10′.

	°	′
Dip by Gambey 1.30 P.M.	81	57·0
„ Fox	81	53·5

Total Force	Relative	Absolute	W.
Fox A	1·8789	14·221	(6·0)
„ C	1·8741	14·184	(2·0)
Lloyd A	1·8752	14·193	(2·0)
„ B	1·8694	14·116	(2·0)
	1·8750	14·191	

August 4.

CXLVI. *On the same day* observed at noon about half a mile below the 'Crooked Spout,' between the same two lakes. Lat. 54° 40′ 51″.

August 4.

CXLVII. *July* 17.—Left camp at 3.10 A.M. Landed for breakfast 7.15 to 8.2. Entered the first Rapid 9.10 and the Crooked Spout at 9.20. Reached the Lower Portage at 10.50 A.M. and observed there at noon. Lat. 54° 43′ 55″.

CXLVIII. Observed near the west end of *Holey*, or *Oxford Lake*. Lat. by account, 54° 46′·8; long. 96° 9′.

Variation, 7.59 A.M. . . . . 12° 53′·6.

August 4.

CXLIX. *July* 18.—Observed on *Holey*, or *Oxford Lake*, near the east end. Lat. by account, 54° 54′·3; long. 95° 40′.

Variation, 8.3 A.M. . . . . 16° 45′·5 E.

CL. On the same day, reached OXFORD HOUSE, about 9.45 A.M., and proceeded after a short delay; but on my return from York Factory, *August* 3, I made observations as follows:—

	°	′
Latitude by Polaris	54	56
Longitude, by two sets of Lunar distances, moon from the sun west of her	95	23
By chronometer	95	38
By Franklin, 1819	95	28
Mean	95	30

The Geological Survey map of 1878 places this Fort in 95° 42′, which appears to be too far to the west.

		°	′
Variation, 5.10 P.M.	. . . . . .	10	31·5 E.
Dip, 5.30 P.M., Gambey	. . . .	82	38·8
,, ,, Fox A	. . . . . .	82	43·4

Total Force	Relative	Absolute	W.
Fox A	1·8820	14·244	(2·0)
Lloyd A	1·8746	14·188	(6·0)
,, B	1·8764	14·202	(2·0)
	1·8764	14·192	(1·0)

All the elements are disturbed at this station.

CLI. Observed at noon on a rocky islet near the *Knife Portage*. Lat. 54° 53′ 4″.

August 3.

CLII. *July* 18 (*resumed*).—Observed at noon at the *Rapid* on *Trout River*. Lat. 54° 52′ 59″. Franklin observed the longitude at Trout Portage, a little to the east, 95° 21′ 9″.

CLIII. Observed on the north side of *Knee Lake*. Lat. by account, 54° 51′; long. 95° 11′.

		°	′	
Variation, 7.54 A.M.	. . . .	13	54·8	
,, 8.19 ,,	. . . .	14	37·6	14° 16′·2

This station is about three miles south from Franklin's 'Magnetic Island' (I. p. 36). Observed lat. 54° 59′. Dr. Bell has a 'Magnetite Island' in lat. 54° 54′, which must be a different one.

CLIV. *August* 3 (*resumed*).—Observed at noon at the 'Second Portage' (F) in Jack River, at the west end. It is probably one of Dr. Bell's 'Drum Portages.' Lat. 55° 13′ 38″.

August 2.

CLV. *July* 19.—This being one of the Göttingen Term-days, devoted to continuous magnetic observation for 24^h, to which much importance was at that time attached, I decided to halt and observe it. The spot selected was the Long Portage on Jack River (450 yards long), between the Drum Portages and the 'Yellow Mud' Portage of Dr. Bell's map. The latter I identify with Franklin's Lower Portage, Jack River. Lat. by observation, 20th, 55° 14′ 1″; long. by observation, 94° 21′ 58″ F. Dr. Bell makes it 94° 33′.

	°	′
Variation, 20th, 5.42 A.M.	12	59·4 E.
„ *August* 2, 6.29 A.M.	12	13·5
	12	36·4

Franklin found in September 1819, 11° 10′·4, and at the Upper Portage, 10° 28′·5.

	°	′
Dip, July 19, 4.30 P.M., Gambey No. 1	82	13·9
„ „ 20, Needle A	82	21·3
„ August 2 „	82	32·2

Total Force	Relative	Absolute	*W.*
July 20, Fox A	1·8749	14·190	(6·0)
August 2 „	1·8815	14·240	(6·0)
„ Lloyd A	1 8742	14·185	(2·5)
July 20, „ B	1·8821	14·245	(2·0)
August 2 „ „	1·8725	14·172	(2·0)
	1·8775	14·210	(1·85)

The Term observations were interrupted by rain from $14^h\ 40^m$ to $17^h\ 10^m$ Gött. ($7^h\ 43^m$ to $9^h\ 13^m$ M.T.). A rather bright aurora was visible for a short time at $19^h\ 20^m$ Gött.; disturbance of moderate amount characterised the whole day, and one very marked movement of declination lasted from 1^h to 8^h Gött., of the 20th (6 A.M. to 1 P.M., M.T.); the easterly declination in that time increased 110 scale divisions, equivalent to 1° 50′, a movement which illustrates the difficulty of ascertaining the true mean declination, or variation, in these latitudes, the time of day being that in which a large proportion of my observations fell.

I left the Long Portage about 3.45 P.M. on the 20th, and encamped at 8 P.M.

CLVI. Observed at noon at the *Creek Portage* (F.), a little to the east of the Mossy Portage of Dr. Bell. Lat. 55° 27′ 16″.

August 1.

CLVII. On the same day observed at the *Devil's Handing Place*, the second portage in Hill River, descending. Lat. by account, 55° 24′; long. 94°.

	°	′
Variation, 8.24 A.M.	11	49·4 E.
Dip, by Gambey No. 1	82	55

Total Force	Relative	Absolute	*W.*
Fox A	1·8844	14·262	(6·0)
Lloyd B	1·8661	14·124	(2·0)
	1·8798	14·227	(0·8)

August 1.

CLVIII. *July* 21.—Observed at *Morgan's Rocks Portage*. Lat. 55° 29′; long. 93° 53′.

Variation, 7.17 A.M. . . . . . . 11° 11′ E.

CLIX.—On the same day observed again at the *White Mud Portage*. Lat. by map, 55° 33′ F.; long. 93° 44′·6.

I passed this spot again on July 31, and made other observations.

	°	′
Variation, July 31, 7.19 A.M.	10	51 E.
Dip, July 21, 1 P.M.	83	2·9
" by Fox A	83	11·6
" 31 "	83	0·

Total Force	Relative	Absolute	W.
July 21, Fox A . .	1·8775	14·210	(6·0)
" 31 " . .	1·8657	14·121	(6·0)
" 21, Lloyd B . .	1·8579	14·062	(2·0)
" 31 " . .	1·8546	14 037	(2 0)
	1·8678	14·134	(1·6)

Dr. Bell observed variation in 1878 a little to the eastward of this station ('Hill River, about twenty miles above its junction with Fox River'), 9° 45′ E., showing a secular change of about − 2′ per annum.

CLX. *July* 22.—Left camp at 2.50 A.M. Observed at noon on *Steel River*. Lat. 56° 11′ 14″.

CLXI. On the same day landed at about 3 P.M. at the junction of the *Shamatawa* with the Steel, or Hayes, or Hill River (this stream is called by these three different names in the last hundred miles of its course). I landed also at the same spot on my return, July 28. Lat. by account, 56° 21′; long. 93° 0′.

	°	′
Variation, July 22, 6.15 P.M.	10	0 E.
" " 28, 4·3 "	12	19·6

These observations are both apparently good, and of equal weight.

	°	′
Dip, July 28, 4 P.M.	83	36·2
" " 22, by Fox	83	41·6
" " 28 "	83	30·2

Total Force	Relative	Absolute	W.
July 22, Fox A . .	1·8648	14·114	(6·0)
" 28 " . .	1·8723	14·171	(6·0)
" 22, Lloyd B . .	1·8637	14·106	(2·5)
" 28 " . .	1·8586	14·089	(2·0)
	1 8666	14·130	(1·65)

CLXII. *July* 23.—I reached YORK FACTORY, on Hudson's Bay, on the forenoon of this day, and remained until the 27th. Lat. by observation at noon, July 24, 56° 59′ 56″.

This differs from Franklin's determination by − 7″ only, and unless the establishment has since been moved, it is laid down on the map of the Geological Survey about 2′ too far north. Long. accepted from Raper, 92° 26′.

		° ′	° ′
Variation, July 24, 6.7 P.M.	. .	9 37·8	9 22·8 E.
" " 6.40 "	. .	9 7·8	
" 26, 7.21 A.M.	. .	8 16·2	8 38·5 E.
" " 7.36 "	. .	9 0·8	
			9 0·6

Lieut. R. B. Blakiston, R.A., who was attached to the Assiniboine and Saskatchewan Exploring Expedition under Captain John Palliser in 1857, as magnetical observer, was sent to join the expedition by way of York Factory, with the object of verifying my observations, more especially those of the force (*see* below) to which a particular interest attached. He found the declination in August, 1857, 7° 37′ [1] E., making it probable that this element attained its easterly extreme at York Factory about the year 1843–4, which was the epoch of a change in another element (the dip) at Toronto.

July 25 was a day of magnetic disturbance generally, especially in the southern hemisphere, and it extended into the 26th. Although no special observations were made there, *it is* plainly traceable in the ordinary readings at Toronto on that day; and I remarked July 26 as a day of disturbance at the time, from the irregular readings of the declinometer. Sabine appears to have rejected the variations observed on that day. Looking, however, to the importance of balancing observations A.M. by observations P.M., I think it better to allow them to stand; making the mean variation 9° 0′·6 E., instead of 9° 25′ E., as previously published.

		° ′
Dip, July 24, 1843, Gambey No. 1, 11 A.M.	.	83 50·5
" " 2, 3 P.M.	.	83 44·0
Mean	. . . .	83 47·2

Having occasion to alter the weight in Lloyd's Static Needle

[1] Sabine, in *Proceedings of Royal Society*, vol. ix. 1859.

No. A at this station, I took the opportunity of observing the dip with it without reversing the poles, giving at 6 P.M. 83° 43′·7. Also on July 25 the dip deducible from the angles of deflection with Fox needle A was 83° 55′·9. These results are not of equal value with the above, and I make no use of them.

Dr. John Rae observed the dip at York Factory at intervals of three or four days from November 5, 1845, to May 16, 1846.[1] The mean of these observations, fifty-two in number, is 83° 42′·57, corresponding to February 9, 1846. On September 18, 1847, he found it 83° 47′·0. The greatest dip observed was 83° 54′·2, on December 3, 1845; and the least, 83° 35′·5, on April 25, 1846. The mean deviation of any one observation from the mean for that month being ± 2′·5. The rate of secular change shown is — 1′·8 per annum.

York Factory, as already remarked, was visited by Lieut. R. B. Blakiston, R.A., in August 1857, when the dip was found to be 83° 53′, whence it would appear to have decreased from 1843 to 1846, and between the latter date and 1857 to have increased again. This is the converse to the secular change experienced at Toronto, where the dip was increasing from 1843 to 1859, and then began to decrease.

Determinations of Total Force.

More than usual interest is given to the observations at this station, and the one last preceding, by the fact that they are the only stations situated to the eastward of the axis of the closed oval of maximum intensity laid down by Sabine; and are, therefore, the principal witnesses to the physical fact of a diminution of intensity as we proceed to the eastward, after passing the meridian of 94° W. on the parallel of 55° N. Gauss's celebrated memoir on the 'General Theory of Terrestrial Magnetism,' published in 1838,[2] had already indicated the existence of such a closed feature, and included this region within it; but its precise geographical place and limits remained to be fixed by observation. The state of disturbance which prevailed at the time of my visit was unfavour-

[1] *Narrative of an Expedition to the Shores of the Arctic Sea.* London: 1850.

[2] Translated by Mrs. Sabine and revised by Sir John Herschel. Taylor's *Scientific Memoirs*, vol. ii. p. 184. 1841.

able; but the observations were multiplied, and their general testimony confirmed by those of Lieut. Blakiston in 1857. There is an exception in the results by Fox's needle C, which I find it necessary to omit. It had undoubtedly contracted rust on the axles, impeding its free movement, and all the angles of deflection are too small.

The following is a summary of the other results:—

Total Force		Relative	Absolute	W.
July 24.	Fox A . .	1·8605	14·081	(6·0)
" "	Lloyd B. .	1·8571	14·056	(2·0)
" 25.	Fox A . .	1·8626	14·097	(6·0)
" "	Lloyd A .	1·8436	13·952	(2·5)
" "	" B .	1·8510	14·010	(2·0)
" 26.	" B .	1·8612	14·087	(2·0)
" "	" B .	1·8608	14·084	(2·0)
		1·8574	14·064	(2·25)

Absolute Horizontal Force.

This observation was made on July 26, which proved to be a day very unfavourable for the purpose. It was a day of considerable magnetic disturbance, besides being so boisterous that a tent put up to shelter the Bifilar magnetometer was blown down between 4 and 5 P.M., rendering the instrument for the time unserviceable. Readings of the Declinometer and Bifilar were taken at intervals of ten minutes during the progress of the observations, but no use can be made of them.

In the reduction of Bar 31 I apply the value of m, determined by the observation preceding and following, to the value of the ratio $\frac{m}{X}$, determined by deflection at two distances, viz.:—

July 14	$m = 0·3906$
August 16	$m = 0·3909$
Mean	0·3907

Also:—

$$u = 28° \; 45'·5 \text{ at } r = 1·0257 \text{ ft. whence } X = 1·4945$$
$$u_1 = 12 \; \; 48·2 \text{ at } r_1 = 1·3257 \quad \text{,,} \quad X = 1·5090$$

The time of vibration of Bar 31 was observed, but is affected by some error, being 7·2275s, which is too little, and I think it necessary to reject it. There is a marginal note in the original entry, 'Q. A movement of the telescope?'

	Observed T s	m	X	ϕ	W.
Magnet 30	6·9613	0·4342	1·5086	13·942	(1·5)
" 31	—	0·3907	1·5018	13·875	(1·0)
			1·5052	13·908	(0·25)

Allowing proportional weight to all the determinations, the mean is 14·051, or 1·8564, and taking 14·203, being the mean at stations CL, CLV, and CLVII, as the force for comparison, we have a reduction amounting to nearly 1·07 per cent., or $\frac{1}{93}$rd part of the quantity, in about 160 miles.

Lieut. Blakiston found the total force in August 1857:—

By statical instruments	14·024
By absolute determinations	14·017
Mean	14·020

I left York Factory on July 28 to return by the same route to Norway House. The observations on this return journey have been given already in their geographical order, but it may be convenient to subjoin the stations of each day in order of date.

Left York Factory at 2.50 A.M. Breakfast halt 7.25 to 8.15.

July 28.—At noon, about five miles below the Shamatawa Station, P.M. Variation at the Shamatawa.

July 29.—Left 4 A.M. Breakfast halt 7.45 to 8.45. Reached *Fox's River* at 4 P.M.

July 30.—Ascending *Hill River*.

July 31.—A.M., at *White Earth Portage*, on Hill River.

August 1.—A.M., at the *Devil's Handing Place*. Noon, at *Creek Portage*.

August 2.—A.M., at the *Long Portage Jack River*. Noon, at the second *Portage Jack River*.

August 3.—A.M., on *Knee Lake*. Noon, on *Knee Lake*, near the Knife Portage. P.M., at *Oxford House*.

August 4.—A.M., on *Holey Lake*. Noon, on *Holey Lake*.

August 5.—P.M., at *White Fall Portage*. Night, at the *Painted Stone Portage*.

August 6.—P.M., on *Hairy Lake*.

August 7.—Noon, on *East River*. P.M., at *Norway House*.

The observations of Sir John Franklin in 1819 on the irregular variations observed on Hayes, Steel, and Hill rivers, between long. 92° 26′ and 94° 22′ W., are borne out by the last five stations. 'The results,' he observes, 'of the observations obtained in Hayes, Steel, and Hill rivers were so very variable that no inference can be drawn from them as to any proportionate increase or decrease of variation in advancing to the westward, and it would be difficult to assign any cause for these irregularities in the two lower rivers, whose banks are entirely composed of alluvial soil. The rocks in Hill River occasionally contained magnetic iron ore.' (I. p. 633.)

The following observation was communicated to me in MS. by Dr. J. Rae, and has not been before published :—

(*b*) At *Fort Churchill.* Lat. by observation, 58° 43′ 50″; long. 94° 14′.

	°	′
Variation, June 29, 1846, A.M.	12	43·0 E.
,, July 1, P.M.	11	29·0 E.
Mean . .	12	6·0 E.
Dip, June 29, Needle 1 D	84	57·5
,, ,, 2 D	84	44·2
,, July 1, Needle 1 D	84	33·9
,, ,, 2 D	84	53·8
,, July 4	84	44·5
Mean . .	84	46·8

The observations of this distinguished Arctic traveller being very nearly related both in time and in geographical connection with my own, and only published in the work already referred to, I subjoin them with his permission, together with a few made by Sir John Richardson and himself in a subsequent voyage (*see* p. 116).

The mean declination at Fort Confidence was 50° 43′·4 E. The mean inclination 84° 50′·6.

The value of the total force deduced by Captain Younghusband from the observations of absolute horizontal force was 13·407, viz. :—

$$\phi = X \text{ secant } \theta$$
$$,, = 1{\cdot}205 \text{ secant } 84^\circ\ 50'{\cdot}6.$$
$$,, = 13{\cdot}407 \quad . \quad . \quad . \quad . \quad . \quad \text{A}$$

But a much higher value resulted from observations with an inclinometer fitted with deflection apparatus, viz. :—

$$\phi = 13{\cdot}886. \quad . \quad . \quad . \quad . \quad \text{B}$$

TABLE XVI.

Stations North of York Factory.

Date	Station	Lat.	Long	Dip	Horiz. Force.	Total Force.[1]	
						A	B
			W				
1846.							
June 20	Creek . .	58° 2·0′	92° 20′	84° 46·4′			
July 1–4	Churchill . .	58 3·50	94 14	84 46·8			
„ 8	Knapp's Bay (1) .	61 9·42	—	86 47·3			
	„ (2) .	64 6·0	88 0	86 36·5			
	Near Wager River	65 10·0	—	87 10·6			
„ 27	Repulse Bay	66 32·0	—	88 16·7			
August 3	3m N.W. of Cape Lady Pelly	—	—	88 27·1			
November	Fort Hope (No. 3)	66 32	86 56·0	88 3·8			
December	„ (No. 4)	„	„	88 14·0			
1847.							
January	„ (No. 1)	„	„	88 17·5			
February	„ (No. 2)	„	„	88 12·2			
1849.							
October	Fort Confidence	66 54	118 49	84 49·4	1·235	13·640	13·402
November	„	„	„	84 51·1	1·198	13·231	13·998
December	„	„	„	84 50·0	1·177	12·999	14·243
1850.							
January	„	„	„	84 48·8	—	—	14·025
February	„	„	„	84 53·9	1·218	13·364	13·894
March	„	„	„	84 50·4	1·198	13·231	13·801

The quantities are very irregular in both series. Applying the mean dip, we have by series A a range from 11·62 to 15·07, and in series B a range from 12·23 to 14·73. The mean of the whole is 13·646, and this agrees best with my observations on Mackenzie's River and Great Slave Lake, viz.—

	Distance	ϕ
At Fort Good Hope	240 miles	13·681
„ Fort Norman	190 „	13·653
„ Fort Simpson	270 „	13·808
„ Fort Resolution	360 „	13·956

It is to be hoped that some light will be thrown on these excessive fluctuations by the observations of the International Circumpolar Expeditions of 1882–3.

[1] See *Magnetical and Meteorological Observations at Fort Confidence in Great Bear Lake*, by Sir John Richardson, C.B.; Reduced and discussed by Capt. Younghusband, R.A. London. 1855.

Dr. R. Bell has favoured me with the subjoined list of variations observed by himself in 1879 at stations intermediate between Dr. Rae's and my own. They refer to an epoch thirty-six years later than the latter, and are therefore adapted to the purpose of giving evidence on the subject of secular change in that interval of time.

The latitudes and longitudes not marked B are taken from his map accompanying a geological report for 1878, unless otherwise explained; but they are very little to be relied on.

TABLE XVII.

Variations North of York Factory, 1879.

	Station	Lat.	Long.	Var.
1	Fort Churchill	58° 43′ 50″	94° 14′	11° 0′ E.
2	Churchill R., 27m from mouth	58 22 0	94 10	6 30
	Churchill R., 22m N. of the mouth of the Little Churchill R.	57 47 0	95 12	15 0
3	At the N. side of the junction of these two rivers	57 31 0	95 30[1]	12 30
4	Little Churchill R., 5m N. of the next station	57 12 0	95 10	10 30
5	Little Churchill R., 24m S. of its junction with the Great Churchill R.	57 7 0	95 0	11 30
6	Nelson R., 63m from N.E. extremity of Beacon Point, or Point of Marsh	56 39 0	94 0	8 45
7	Nelson R., lowest Limestone Rapid, 77m from Point of Marsh	56 36 1[2] B	94 15	11 30
8	Nelson R., Broad Rapid, 23m S.W. from the last	56 35 0	94 55	11 30
9	Nelson R., outlet of Split Lake[3]	56 16 5 B	97 10	18 0
10	Grass R., outlet of Witchin, or Stinking Lake	56 13 0	97 13	16 30
11	Nelson R., N. side of outlet of Sepiwesk Lake, at S. end of Cross Portage	55 13 5 B	97 50	16 30
12	Nelson R., Duck Portage, outlet of Duck Lake	54 53 0	98 20	19 15
13	Nelson R., 2m below White Mud Falls	54 45 8 B	98 10	14 30
14	Western Channel of East R., 5m S. of Pipestone Lake	54 38 0	98 5	16 30
15	Junction of Pine R. and East R., 6m below Sea River Falls	54 20 0	97 47	16 0

[1] So Dr. Bell. On the Dominion map it is in about 94° 50′.

[2] By the map, about 56° 30′.

[3] By the latitude given, this must be the entrance, not the outlet, going by the current.

SECTION IV.

NORWAY HOUSE, LAKE WINNIPEG, TO FORT CHIPEWYAN, LAKE ATHABASCA.

About 1,090 *miles.*

August 12, 1843.—I left Norway House at 3.30 A.M., following the Saskatchewan brigade of boats, which had started the previous day.

Before quitting the station I substituted a new axle for the unserviceable one of Fox's needle C, and took two complete sets of observations to furnish a base for future intensities referred to Norway House.

Weight	Angle	Nat sin W.
	° ′	
1·5 grs.	19 32·2	·1115
2·0 "	26 24·5	·1131
2·5 "	34 12·0	·1125
3·0 "	42 42·1	·1130
3·5 "	52 33·0	·1139

Observed in the middle of the day at *Old Norway House*, already given as Station C. I observed again the temperature of boiling water, for the purpose of ascertaining the height of the lake above the sea. This was done on many occasions, and gave a mean elevation of 773 feet. It has since been determined by the surveyors of the Canada Pacific Railway to be about 710 feet, the elevation currently adopted. Encamped at 8 P.M.

CLXIII. *August* 13.—Started at 4 A.M. Observed on the *North Shore*, in lat. 53° 53′; long. 98° 39′.

		° ′	
Variation, I. 8.9 A.M.	. .	17 35·8 E.	17° 24′·2 E.
" II. 8.16 "	. .	17 6·6	
" III. 8.37 "	. .	17 30·3	

CLXIV. Observed lat. at noon from the lake horizon, 53° 50′ 24″; a bed of peat about 8 feet thick here formed a cap to the low cliff forming the lake shore.

CLXV. Observed again on *Macintosh Island*, an island off *Limestone Point*, not named on Dr. Bell's map. Lat. 53° 40′; long. 99° 5′ F. (Bell, 99° 15′).

	°	′	
Variation, I. 2.54 P.M. . . .	21	57·6	21° 39′·4 E.
„ II. 3.5 „	21	21·2	

I did not note the geological formation of Macintosh Island, and the observation was not reduced until long after I had quitted it; but I have little doubt that it will prove to be an island of some intrusive formation, upstanding in the limestone basin of the lake.[1]

CLXVI. We encamped at 8 P.M. at what proved to be, after we were landed, a mere bank of sharp limestone shingle, between the lake and a swamp, where it was difficult to find a smooth place for sleeping.

August 14.—We were detained at this spot until six in the evening by a heavy swell from the lake, which made it impossible to proceed. The formation was limestone, abounding in fossil fish, orthocerata, and trilobites of large size. Observed lat. 53° 31′ 54″; long. 99° 12′.

	°	′
Variation, 8.14 A.M.	17	7·3
Dip, 5 A.M., Gambey No. 1	80	16·8
„ Fox A gave	80	19·7
„ C „	80	30·0
Mean	80	22·2

In this case the dip by Gambey appears to be less than it should be, the station being presumably, from its geological formation, free from disturbance.

Total Force	Relative	Absolute	W.
Fox A	1·8721	14·169	(6·0)
„ C	1·8576	14·060	(4·0)
Lloyd A	1·8585	14·066	(2·5)
„ B	1·8627	14·098	(2·5)
	1·8627	14·098	(1·5)

[1] Sabine omitted the observation.

This station was formerly described as near the 'First Rocky Point' of Franklin, but the latitude is that of his 'Second Rocky Point,' which agrees better with a run of 4^h or 5^h from Macintosh Island.

We were enabled to proceed at 6 P.M., and encamped four or five miles further on, at the mouth of Buffalo River. The spot is identified by the descriptive particulars given in a letter written a few days later. 'A narrow channel hardly visible from the lake, opening through a white shingly beach, which led us into a considerable lake or bay, totally landlocked, with black water, which contrasted curiously with the chalky tint of Lake Winnipeg.' The canoe had to be sent back from here to the place of the morning's detention, which was but three or four miles off.

CLXVII. *August* 15.—Left at 2 A.M. Observed at the mouth of the *River Saskatchewan*. Lat. 53° 17′; long. 99° 25′.

Variation, 7.56 A.M.	16° 39′·2 E.

'The N.E. side of the actual mouth of the river was bearing N. 30° E. at half a mile distance.'

CLXVIII. Observed at noon, having entered the river. Lat. 53° 10′ 38″.

CLXIX. Observed again at the lower (east) end of the *Grand Rapid*, which was also a station of *September* 2, 1844, when, however, we ran the rapid in flood instead of making a portage, one of the most hazardous experiences of my voyage. Lat. by account, 53° 8′; long. 99° 27′.

Franklin observed at the other, or west end. Lat. 53° 8′ 25″; long. 99° 28′ 2″.

	°	′
Variation by compass, August 15, 1843, 4.14 P.M.	19	12·9 E
" collimator, September 2, 1844, 9.43 A.M.	17	25·0
Mean	18	19·0 E.

Only one limb of the sun could be seen on the last occasion.

	°	′
Dip, 1843, Gambey No. 1, 6.30 P.M. . . .	80	21·5
" 1844, " " " A.M. . .	80	31·6
Mean	80	26·5

Total Force		Relative	Absolute	W.
1843.	Fox A . .	1·8741	14·184	(6·0)
,,	,, C . . .	1·8608	14·084	(4·0)
1844.	Lloyd B . .	1·8760	14·199	(2·5)
	Mean . .	1·8702	14·155	(1·25)

Horizontal force in absolute measure, 1844 :—

	Corrected T s	m	X	φ	W.
By Magnet No. 30	4·8097	0·3975	2·3469	14·134	(1·0)
,, ,, 31	5·1558	0·3514	2·3395	14·089	(1·0)
,, ,, 17	5·3157	0·6700	2·3388	14·085	(1·0)
				14·102	(0·3)

The mean, allowing weight as above, is 1·8684, or 14·141.

I halted at the upper end of the portage, and there found the Saskatchewan brigade of boats, under Mr. Harriot, already encamped.

CLXX. *August* 16.—Started before the Brigade, and reached *Cross Lake*, about half a dozen miles above the Rapid. Two or three hours later the Brigade came up, and here we were all detained by wind on the east side of the lake until late in the afternoon of the following day. Observed at noon. Lat. 53° 10′ 7″; long. 99° 34′.

Variation, 9.34 A.M.	18°	3′·7 E.
Dip, P.M., Gambey No. 1	80	28·2

Total Force	Relative	Absolute	W.
Fox A	1·8761	14·197	(6·0)
,, C	1·8552	14·041	(4·0)
Lloyd B	1·8767	14·204	(2·5)
Mean . .	1·8695	14·150	(1·25)

Horizontal force in absolute measure, by vibration and deflection :—

	Corrected T s	m	X	φ	W.
Magnet 30	5·6034 ♒	0·4306	2·3477	14·177	(1·5)
,, ,,	4·6167	0·4310	2·3495	14·187	(1·5)
,, 31	5·8808 ♒	0·3909	2·3479	14·178	(1·5)
,, ,,	4·8516	0·3931	2·3614	14·256	(1·5)
				14·199	(0·6)

The letter ♒ indicates that the bar was vibrated in a stirrup.

Combining these values by weight, the mean for the station is 1·8624, or 14·096.

August 17.—The wind subsided, and we were enabled to advance towards evening, experiencing considerable difficulty in finding a landing place. 'We reached a small lake, or expansion of the river, which was so shallow that we searched a long time for a place where we could approach the shore. At last we succeeded, and after forcing my way through reeds and rushes almost as high as myself, I found a tolerably clear space, where we slept without a tent, as the place did not admit of unloading the canoe' (Letter).

CLXXI. *August* 18.—Left at 4 A.M. Observed at noon on *Hare Island* (Isle aux Lievres), *Cedar Lake*, a narrow limestone island about the middle of the lake. It is not named on my map, but is probably off Rabbit Point, called by Franklin 'Long Point.' Lat. 53° 12′ 9″; long. 100°.

Dip, Gambey No. 1. . . . . . . 80° 7′·1

Total Force	Relative	Absolute	*W.*
Fox A	1·8581 [1]	14·063	(0·6)

CLXXII. Observed for time at 4 P.M., on another island on the west side of the lake. Lat. 53° 17′·8; long. 100° 12′.

CLXXIII. *August* 19.—Observed on the west shore of *Muddy Lake*, in what is marked on some maps as the delta of the Saskatchewan. Lat. 53° 19′·3; long. 100° 35′.

Variation, 7.48 A.M. . . . . . . 18° 32′·9 E.

CLXXIV. I observed on Isle des Festins, or *Devil's Drum Island*, about a quarter of a mile north-west of the last station. Lat. 53° 19′·5; long. 100° 36′. Both spots are in the limestone district, and scarcely require to be regarded as separate stations.

	°	′
Variation by collimator, 7.30 A.M. . . .	17	32·2 E.
Dip, Gambey No. 1	80	0·0

Horizontal force in absolute measure:—

	Corrected T s	*m*	*X*	*φ*	*W.*
Magnet 30	4·7485	0·3975	2·4078	13·866	(1·0)
" 31	5·0968	0·3514	2·3940	13·786	(1·0)
" 17	5·1934	0·6700	2·3947	13·790	(1·0)
			2·3988	13·814	(0·3)

September 1, 1844.

[1] Formerly given 1·871, which is incorrect.

CLXXV. Encamped on the most westerly of the *Pine Islands*, and observed lat. by Polaris, 53° 30′ 45″.

August 31, 1844.

CLXXVI. *August* 19 (*resumed*).—Observed at noon. Lat. 53° 30′ 51″.

CLXXVII. *August* 20.—Left camp at 3.20 A.M. Observed at noon. Lat. 53° 46′ 47″.

In the afternoon I visited the missionary station of Christchurch, otherwise called *The Pas*, then in its infancy, and in temporary charge of a young half-breed catechist named Budd.

CLXXVIII. Encamped about four miles beyond this place, probably at the *Round Turn*, a well-marked spot, and observed lat. by Polaris, 53° 48′ 51″; long. 101° 23′.

Returning to the same spot *August* 31, 1844, I made other observations.

	°	′
Variation by collimator, 10.39 A.M. . . .	19	56·8 E.
Dip, Gambey No. 1	80	24·4

Horizontal force in absolute measure:—

	Corrected T	m	X	φ	W.
	s				
Magnet No. 30	4·7705	0·3975	2·3857	14·315	(1·0)
„ „ 31	5·1090	0·3514	2·3835	14·296	(1·0)
„ „ 17	5·1978	0·6700	2·3905	14·344	(1·0)
			2·3866	14·318	(0·3)

CLXXIX. *August* 21.—Left 3.55 A.M. Observed a little to the eastward of the *Big Bend*. Lat. 53° 52′; long. 101° 28′.

Variation, 8.6 A.M. . . . . . . 20° 45′·4 E.

CLXXX. Observed at noon at the *Big Bend*. Lat. 53° 58′ 22″.

CLXXXI. *August* 22.—Left 3.40 A.M. Observed to the eastward of the channel called the *Little River*, which is one of the arms into which the Saskatchewan divides above Cumberland House, apparently the same as 'Tearing River' on recent maps. Lat. 53° 51′; long. 101° 50′.

Variation, 7.32 A.M. . . . . . . 17° 45′·2 E.

This result is irregular, and as the observation was good, seems to indicate local disturbance.

CLXXXII. Observed at noon about one mile south-east of the small lake formed by an expansion of the *Little River*. Lat. 53° 52′ 42″.

Cumberland House was reached about 6 P.M.

Cumberland House.

CLXXXIII. The latitude and longitude of this station having been determined by the officers of Franklin's first expedition, who wintered here in 1819, and again in 1825, I adopted their results, and made use of the longitude for rating my chronometer. Lat. 53° 56′ 40″; long. 102° 19′ 13″, or $6^h\ 49^m\ 16^s$ W.

It is so placed in the map of the North-West Territory, dated 1882. I observed here both going and returning.

	°	′
Variation by compass, August 23, 1843, 7.30 A.M. .	19	52·4 E.
,, ,, ,, ,, 7.58 ,, .	19	43·8
	19	48·1
Variation by collimator, August 29, 1844, 5·39 P.M.	19	16·7 E.
Mean	19	32·4 E.

	°	′		
Dip, 1843, 7 A.M., Gambey No. 1 . .	80	28·2		
,, ,, ,, ,, ,, 2 . .	80	31·8		
			80	30·0
,, 1844, P.M. ,, ,, 1 . .	80	20·5		
,, ,, ,, ,, ,, 2 . .	80	19·5		
			80	20·0
			80	25·0

	Total Force	Relative	φ	W.
August 23, 1843.	By Fox A .	1·8639	14·107	(6·0)
,, ,,	,, B .	1·8726	14·173	(4·0)
,, ,,	,, C .	1·8510	14·010	(4·0)
August 24 ,,	,, A .	1·8718	14·167	(6·0)
,, ,,	,, B .	1·8723	14·171	(4·0)
,, ,,	,, C .	1·8689	14·145	(4·0)
,, ,,	By Lloyd B (1) .	1·8680	14·138	(2·5)
,, ,,	,, (2) .	1·8703	14·156	(2·5)
		1·8686	14·1420	(3·3)

By complete observations of vibration and deflection :—

		Corrected T (s)	m	X	φ	W.
Aug. 23, 1843.	Magnet 30	5·5994 §	0·4317	2·3452	14·209	(1·5)
	„ „	4·6163	0·4316	2·3449	14·207	(1·5)
„	„ 31	5·9089 §	0·3920	2·3375	14·163	(1·5)
„	„ „	4·8845	0·3919	2·3368	14·158	(1·5)
					14·1842	(0·6)

I here apply the dip observed in 1843.

By observation of vibration only, August 29, 1844 :—

	Corrected T (s)	m	X	φ	W.
Magnet No. 30	4·7775	0·3976	2·3782	14·163	(1·0)
„ „ 31	5·1080	0·3515	2·3828	14·191	(1·0)
„ „ 17	5·2355[1]	0·6700	2·3562	14·032	(1·0)
				14·129	(0·30)

I here apply the dip observed in 1844.

We have thus seven independent determinations for Cumberland House; and allowing weight as here assigned, the mean is, total force in relative value, 1·8686; in absolute value, 14·143.

August 24, 1843.—Left Cumberland House in the afternoon for Isle à la Crosse, but was obliged to land soon after on a small island in *Pine Island Lake*, about two miles distant from the Fort, and wait until the wind abated.

Observations on the Saskatchewan above Cumberland House will be found below, Stations CCLXXX to CCXC.

CLXXXIV.—Station in *Pine Island Lake*, about two miles from Cumberland House. Lat. by account, 53° 58′; long. 102° 17′.

The planet Jupiter being favourably situated about 12° above the horizon, I took two sets of azimuths for variation.

	hour angle (h m)		var. (° ′)
At 8.22 P.M.,	3 3	var.	17 58 E.
„ 8.29 „	3 10	„	18 1·4
			17 59·7 E.

CLXXXV. *August* 25.—Left at 4 A.M., traversed Pine Island Lake of Franklin, 'Beaver or Sturgeon' lake on modern maps. Observed from the lake horizon at noon, lat. 54° 14′ 34″; encamped on the *River Malign*, a voyageur's name for the shallow, tortuous,

[1] Not as previously published, 5·2235 s.

rapid stream flowing out of Beaver Lake proper, which is to the north of Pine Island Lake. The River Malign is Sturgeon River of Franklin's Tables, but not named on his map.

CLXXXVI. *August* 26.—On the *River Malign*, observed A.M. in lat. by account 54° 21′·4; long. 102° 10′.

Variation, 8.35 A.M. . . . . 21° 23′ E.

CLXXXVII. Observed about 17^m past noon on an island in the stream above *Crooked Rapid*. Lat., by reduction to meridian, 54° 23′ 17″.

CLXXXVIII. Entered Beaver Lake, and observed on *Limestone Point*, near the outlet. Lat. by account, 54° 26′; long. 102° 10′.

Dip by Gambey No. 1, 2–3 P.M. . . . 80° 34′·2

Total Force	Relative	Absolute	*W.*
Fox A	1·8630	14·100	(6·0)
„ C	1·8398	13·925	(4·0)
	1·8537	14·030	(1·0)

I commenced at this station a practice which was continued until my arrival at Lake Athabasca, of observing at all favourable opportunities the time of vibration of the three magnets numbered respectively 30, 31, and 17, for the relative horizontal force at the station, as a confirmation of the observations of relative total force.

On comparing the magnetic moment of these magnets, as ascertained at Cumberland House on August 24, with its amount at Isle à la Crosse on September 11, a very evident reduction is seen.

Values of m.

	Cumberland House Day 236 (Aug. 24) Corrected T s	Isle à la Crosse Day 252 (Sept. 9) *m*	Ft. Chipewyan Day 286 (Oct. 13) *X*
Magnet 30 . .	0·7036	0·6920	0·6882
„ 31 . .	0·4312	0·4155	0·4173
„ 17 . .	0·3921	0·3848	0·3855

This loss occurred in eighteen days, and there is no decisive evidence whether it was progressive or resulted from some accident affecting them all together; on that account Sabine recorded the results (Table XLII), but did not make use of them. I do not, however, consider the error possibly involved in the supposition that it was uniform and progressive, one which necessitates their entire exclusion from view, as they do in fact when so treated give support to the results derived from the Fox and Lloyd needles. From Isle à la Crosse to Lake Athabasca the magnetism was nearly stationary, the amount of change being at least insignificant.

In the subjoined conversions I have applied a value of m = the magnetic moment of the bar on the day of observation, by simple interpolation, on the supposition of uniform change.

August 26.—On *Beaver Lake* (*continued*).

	Corrected T (s)	m	X	ϕ	W.
Magnet No. 30	4·6671	0·4289	2·3101	14·100	(1·0)
„ 31	4·9447	0·3908	2·2869	13·958	(1·0)
„ 17	5·2050	0·7015	2·2769	13·898	(1·0)
			2·2913	13·985	(0·3)

The mean by both methods, weighted as above, is 1·8540, or 14·032.

CLXXXIX. *August* 27.—Left 3.30 A.M., observed at noon about 1½ mile north of the mouth of *Hay River*, a stream flowing from the west, which is inserted on Franklin's route, but not marked on recent maps. Lat. 54° 42′ 55″.

CXC. Reached the *Carp Portage*, on 'Great River.' Lat. by account, 54° 47′·2; long. 102° 39′·5 F. (by chron. 102° 46′·6), and observed:

	°	′
Variation, 2.23 P.M.	24	8·6 E.
Dip by Gambey No. 1, 1.30 P.M. . . .	80	39·6

Force *not observed.*

CXCI. *August* 28.—Left at 4.10 A.M. Observed at the *Pine Portage*, or P. des Epinettes, leading into Heron Lake. Lat. by Franklin's map, 55° 4′; long. 102° 42′ F.

	°	′
Dip, Gambey No. 1, at 11 A.M.	80	52·7

Total Force	Relative	Absolute	W.
Fox A	1·8714	14·167	(6·0)
„ C	1·8549	14·039	(4·0)
	1·8642	14·051	(1·0)

	Corrected T s	m	X	φ	W.
Magnet No. 30	4·7471	0·4270	2·2395	14·137	(1·0)
„ 31	5·0066	0·3900	2·2353	14·100	(1·0)
„ 17	5·2725	0·7001	2·2229	14·022	(1·0)
				14·086	(0·3)

Mean of both, 1·8677, or 14·136.

CXCII. *August* 29.—Left 4 A.M., reached the FROG PORTAGE, leading into English or Churchill River. Lat. by account, 55° 27′; long. 103° 19′·5 F.

Observed dip, Gambey No. 1, 3.20 P.M. . . . 80° 59′·3

Total Force	Relative	Absolute	W.
Fox A	1·8555	14·044	(6·0)
„ C	1·8462	13·973	(4·0)
	1·8518	14·010	(1·0)

	Corrected T s	m	X	φ	W.
Magnet No. 30	4·7865	0·4260	2·1113	14·117	(1·0)
„ 31	5·0492	0·3896	2·2001	14·046	(1·0)
„ 17	5·3184	0·6994	2·1873	13·964	(1·0)
Total force by vibration only				14·042	(0·3)

Mean by both observations, weighted as above, 1·8520, or 14·017.

We here enter what is called on the maps the Missinnipi, Churchill, or English River, a succession of irregular basins connected by channels of erosion in granitic rocks. The valuable *résumé* of information respecting this region, compiled by Mr. Sandford Fleming, which qualifies every square of one degree, had, so late as 1879, the stereotyped phrase 'nothing reliable known' against every section.[1] The state of the weather in my passage almost precluded observation, and such memoranda as were made are lost.

August 30.—No observations. The rain was almost unceasing about this time.

CXCIII. *August* 31.—Observed at a portage, of which the name is not recorded, about three miles west of Rapid River. Lat. by account, 55° 26′; long. 104° 26′ F. (chron. 104° 42′). The sun was clouded over after the sights for time, and only one sight could be obtained for variation, giving at 9.11 A.M. variation 25° 21′ E.

[1] Report addressed to the Hon. the Minister of Public Works, Ottawa, 1879.

CXCIV. Observed at noon, about five miles south of the *Mountain Portage.* Lat. 55° 29′ 37″.

CXCV. Observed again at *Little Rock Portage,* next beyond and near the last station. Lat. 55° 30′; long. 104° 34′.

	°	′	
Variation, 4.18 P.M. . . .	16	35·0 E.	16° 27′·3 E.
„ 4.51 „ . . .	15	16·3	
„ 5.10 „ . . .	17	1·4	

This result indicates a powerful local disturbing influence, of which there are traces in all the observations of the next three days. The formation is gneiss and mica slate, but its relations to the Winnipeg limestones are not determined, and whether the two meet in this neighbourhood or not has yet to be determined. I have subjected the observations to close scrutiny and find nothing to suggest a doubt of their accuracy. The other elements show a like disturbance.

Dip, 3.30 P.M., Gambey No. 1 . . . . . 80° 16′·4

Total Force	Relative	Absolute	W.
Fox A	1·9961	15·107	(6·0)
„ C	1·9842	15·018	(4·0)
	1·9913	15·071	(1·0)

This is a very unusual and excessive force, but was exceeded on Lake Winnipeg, Station CXXI, and on Lake Superior, Station LII. The dip is about 20′ less than is due to the position.

CXCVI. Observed again at the place of encampment not far from *Otter Portage.* Lat. by Polaris, 55° 36′ 18″; but by meridian altitudes of *a*Aquilæ 55° 35′ 41″; long. by chron. 104° 56′.

CXCVII. *September* 1.—Observed at the east end of *Great Devil's Portage.* Lat. 55° 40′; long. 104° 47′ 46″ F. (By chron. 105° 6′·6.)

	°	′
Variation, 9.27 A.M.	24	48·5 E.
Dip, Gambey No. 1, 10 A.M.	80	30·9

Total Force	Relative	Absolute	W.
Fox A	1·8670	14·131	(6·0)
„ B	1·8666	14·127	(4·0)
	1·8668	14·129	(1·0)

	Corrected T s	m	X	ϕ	$W.$
Magnet No. 30	**4·7649**	**0·4201**	**2·2414**	**13·600**	(0·0)[1]
" " 31	4·9375	0·3883	2·3086	14·010	(1·0)
" " 17	5·1829	0·6959	2·3101	14·019	(1·0)
			2·3093	14·014	(0·2)

Mean, allowing weight as above, 1·8653, or 14·118.

CXCVIII. Observed at noon at the upper end of the same portage. Lat. 55° 40′ 26″.

CXCIX. Observed at the encampment *Portage des Ecores* (Steep-Bank Portage, Richardson). Lat. by Polaris, 55° 42′ 23″; long. (by chron.) 105° 29′·4.

CC. *September* 2.—Observed at *Trout Portage*, English river. Lat. by account, 55° 42′·5; long. 105° 29′. (By chron. 105° 30′.)

		°	′
Variation, 8.26 A.M.	. . . . . .	21	31·1 E.
" 8.32 "	. . . . . .	21	24·9

CCI. Observed at noon at a spot about one and a quarter mile south-east from Harriet Portage. Lat. 55° 34′ 3″.

CCII. Observed again at the encampment, about half a mile

[1] The time of vibration of Magnet 30 is anomalous, and the observation must be rejected. I subjoin the details of it. Ther. 72°·7.

No.	Chron. Time.	No.	Chron. Time	200 Vibr.	
	h. m. s.		h. m. s.	m. s.	
0	6 33 5·0	200	6 49 0·8	15 55·8	
10	6 33 53·0	210	6 49 49·0	15 56·0	
20	6 34 41·0	220	6 50 36·0	15 55·0	
30	6 35 28·5	230	6 51 23·8	15 55·3	
40	6 36 16·0	240	6 52 11·4	15 55·4	
50	6 37 3·8	250	6 52 59·5	15 55·7	
60	6 37 52·0	260	6 53 47·0	15 55·0	
70	6 38 39·8	272	6 54 44·8	15 55·4	
80	6 39 27·5	280	6 55 22·8	15 55·3	
90	6 40 16·0	290	6 56 10·5	15 54·5	
100	6 41 2·5	300	6 56 58·0	15 55·9	
Mean time of 200 vibrations.				15 55·35	Obs. T. of 1 vibr. 4·7768 secs.

The interval should have been 13·0 secs. *less*, to give a result in agreement with Nos. 31 and 17. A loss of magnetic moment amounting to 0·0115 would account for the difference, and the bar does evince a loss of magnetism on following days.

above the Cardinal Rapid, at the west end of Black Bear Island Lake F. Lat. by Polaris, 55° 39′ 4″.

CCIII. *September* 3.—Left about 5 A.M. Observed about one mile below the 'Rapide qui parle' (*voyageur* ellipsis for 'Rapide qui *ne parle pas*,' in allusion to its swift and silent current). Lat. by account, 55° 43′·5; long. 105° 50′ F. The position by chronometer was 106° 28′, which I cannot reconcile with the map or with next day's sights, and therefore disregard.

	°	′
Variation, 7.59 A.M.	20	31·9 E.
„ 8.4 „	21	38·3
„ 8.31 „	21	37·1
Mean	21	15·9

CCIV. Observed 50ˢ before noon at *Canoe Portage*. Lat. by a single sight reduced, 55° 40′ 30″±1′;[1] long. 105° 58′.

CCV. Observed at the *Pine* or *Pin Portage*, at the east end of Sand-fly Lake. Lat. 55° 43′; long. 106° 0′.

Dip, Gambey No. 1, 4.30 P.M. . . . . 80° 40′·3

Total Force	Relative	Absolute	W.
Fox A	1·8597	14·078	(6·0)
„ C	1·8519	14·017	(4·0)
	1·8566	14·052	(1·0)

	Corrected T s	m	X	φ	W.	
Magnet No. 30	4·7953	0·3875	2·2360	13·795	(0·0)[2]	*rejected*
„ „ 31	5·0187	0·4213	2·2461	13·856	(0·0)	*rejected*
„ „ 17	5·2492	0·6959	2·2675	13·989	(1·0)	

Mean for the station, 1·8524, or 14·023.

CCVI. *September* 4.—Observed at *Snake Point*. Lat. by account, 55° 51′; long. 106° 30′ 1″.[3] By chron. 106° 38′.

	°	′
Variation, 8.7 A.M.	26	34 E.
„ 8.35 „	26	1·7 E.

CCVII. Observed again at *Snake Rapid*, at noon. Lat. 55° 44′ 8″; long. 106° 35′ 2″.

[1] It is not noted which side of the horizon-glass faced the sun.

[2] Evident loss of magnetism.

[3] Franklin has an observation for longitude in 1826, 'in the narrows between Sandfly and Snake Lake,' 106° 44′ 36″, by which this place seems intended, but it does not fit the map, which was drawn on observations of 1819 only.

Dip, 1.30 P.M., Gambey No. 1 . . . 80° 38′·8

Total Force	Relative	Absolute	W.
Fox A	1·8731	14·177	(6·0)
„ C	1·8641	14·109	(4·0)
„ B	1·8560	14·048	(4·0)
	1·8649	14·128	(1·4)

	Corrected T s	m	X	X sic φ	W.
Magnet No. 30	4·7605	0·4203	2·2657	13·940	(0·0)
„ „ 31	4·9833	0·3877	2·2733	14·020	(0·0)
„ „ 17	5·2308	0·6952	2·2697	13·966	(0·0)

These values indicate loss of force, and are rejected.

I was detained for some time at this station, being obliged to send back the canoe down the Rapid, which we had just mounted with much labour, to Snake Point, for a bag of 'Taureau' (Pemmican) left behind by negligence of the men.

There was the first decided frost this night since June 8.

CCVIII. *September* 5.—No observation, probably on account of weather. Encamped on Knee Lake. A single sight of Polaris gave lat. 55° 48′ 48″.

CCIX. *September* 6.—Incessant rain; but I obtained two momentary sights of the sun on *Primeau Lake*. Lat. by account, 55° 57′; long. about 107° 10′; whence

Variation, 8.28 A.M. . . . 23° 15′·9 E.

CCX. *September* 7.—Observed at the *Portage Sonnante*, at the outlet or north-east end of Lake à la Crosse. Lat. by Franklin's map, 55° 54′; long. 107° 36′.

	°	′
Variation, 4.13 P.M.	26	43·4 E.
Dip, Gambey No. 1, P.M.	80	11·2

Total Force	Relative	Absolute	W.	
Fox A	1·8571	14·056	(6·0)	
„ C	1·8073 [1]	13·679	(0·0)	*rejected*

[1] Needle C had evidently lost magnetism by some accident since the 4th instant, and continued to give values of the force materially below those given both by needle A and by the method of vibration, until my arrival at Fort Chipewyan. The difference is about 2 per cent. I have continued, however, to insert the values actually found for the sake of the confirmation they afford to the exceptional force at Station CCXXV (*Pierre au Calumet*), as assigned by needle A. *See* p. 140.

	Corrected T s	m	X	ϕ	W
Magnet No. 30	4·6472	0·4177	2·3960	14·058	(1·0)
„ „ 31	4·8831	0·3858	2·3796	13·962	(1·0)
„ „ 17	5·0994	0·6936	2·4013	14·095	(1·0)

I. Total force by vibration only	14·038	(0·3)
II. „ „ Fox's needle A	14·056	(0·6)
	14·050 or 1·8563	

September 8.—Observation was again prevented by rain. I reached the Hudson's Bay Fort, on Lake à la Crosse, in the evening.

CCXI. *September* 9.—At the Hudson's Bay House, or Fort, on Isle à la Crosse Lake. Latitude observed at noon, 55° 26′ 45″; by Polaris, 9.11 P.M., 55° 26′ 53″.

The first is identical with Franklin's latitude in 1819. Simpson made it only 55° 25′ 25″ in 1836, which is evidently too little.

I assume the long. as 107° 53′ 57″ W., or $7^h\ 11^m\ 36^s$, being the mean of the following determinations :—

	°	′	″
Franklin, 1819	107	52	45
„ 1826	107	54	36
Simpson, 1836	107	54	30

	°	′	
Observed variation, 8.26 A.M.	24	57·5	E.
„ „ 8.54 „	24	35·0	E.
„ „ 5.30 P.M.	25	11·7	E.
Mean	24	54·7	E.

	°	′
Dip, Gambey No. 1, 6.30 A.M.	80	9·1
„ „ „ 2, 7.30 „	80	10·5

Total Force	Relative	Absolute	W.
Fox A (1)	1·8577	14·045	(6·0)
„ „ (2)	1·8542	14·034	(6·0)
„ B (1)	1·8494	13·998	(4·0)
„ „ (2)	1·8479	13·986	(4·0)
„ C	1·7999	13·623	(0·0)
„ „	1·7962	13·595	(0·0)
Lloyd B (1)	1·8460	13·972	(2·5)
„ (2)	1·8460	13·972	(2·5)
Mean .	1·8535	14·028	(1·9)

Horizontal force in absolute measure :—

	Corrected T s	m	X	ϕ	W.
Magnet No. 30	5·6434 ♄	0·4178	2·3861	13·967	(1·5)
„ „	4·6589	0·4198	2·3968	14·030	(1·5)
„ No. 31	5·9081 ♄	0·3841	2·3868	13·971	(1·5)
„ „	4·8838	0·3840	2·3860	13·966	(1·5)
„ No. 17	5·1161	0·6920	—	—	(1·0)

	X	φ	W.
By vibration and deflection . . .	2·3889	13·983	(0·6)
„ only (17)	2·3891	13·984	(0·1)
By Fox's needles A–B	—	14·020	(2·0)
„ Lloyd's needle B	—	13·972	(0·5)

The mean according to weights is 1·8520, or 14·012.

September 11.—Left the Fort at 11.40 A.M. Encamped at 7 P.M. No observations.

September 12.—Left camp at 4 A.M. Observation was again prevented by wet weather.

CCXII. *September* 13.—Observed towards the northern end of *Buffalo Lake.* Lat. by account, 56° 4′; long. 108° 40′.

Dip, by Gambey No. 1, 7 A.M. . . . . . 80° 37′·0

Total Force	Relative	Absolute	W.	
Fox A	1·8545	14·036	(6·0)	
„ C	1·7862	13·529	(0·0)	*rejected*

	Corrected T s	m	X	φ	W.
Magnet No. 30	4·7694	0·4155	2·2833	14·033	(1·0)
„ „ 31	4·9986	0·3841	2·2730	14·005	(1·0)
„ „ 17	5·2358	0·6912	2·2880	13·924	(1·0)
				13·993	(0·3)

The mean adopted is 1·8526, or 14·022.

CCXIII. Observed at noon on *Buffalo Lake.* Lat. 56° 7′ 14″. The place of A.M. observation was in sight, bearing E. 10″ S., at about three miles distance.

CCXIV. Observed again on the *Methy River.* Lat. by Polaris, 56° 12′ 35″; long. 109° F. (109° 9′·4 chron.).

CCXV. *September* 14.—Observed at the north end of the *Long Portage*, on Methy River (or River de la Loche), three and a half miles. Lat. by observation, 56° 14′ 41″; long. 109° 18′ F. (chron. 109° 22′·5).

	°	′
Variation, 9.35 A.M.	28	40·6 E.
„ 9·43 „	28	27·5
Dip, Gambey No. 1, 10.15 A.M.	80	19·7

Total Force	Relative	Absolute	W.
Fox A	1·8239	13·836	(6·0)
„ C	1·8021	13·640	(0·0)

	Corrected T s	m	X	φ	W.
By Magnet No. 30	4·7106	0·4155	2·3408	13·935	(1·0)
„ „ 31	4·9345	0·3841	2·3323	13·883	(1·0)
„ „ 17	5·1690	0·6910	2·3437	13·950	(1·0)
				13·922	(0·3)

Mean, by weight, 1·8320, or 13·865.

CCXVI. *September* 15.—Left at 4.10 A.M. Observed at the *Pine Portage.* Lat. 56° 20′; long. 109° 14′ F.

	°	′
Variation, 8.2 A.M.	25	34·9 E.
„ 8.12 „	25	24·1

Encamped at the Methy Portage.

CCXVII. *September* 16.—At the Portage de la Loche, or *Great Methy Portage,* so called pre-eminently, being about twelve miles in length. Observed at the south-east end. Lat. by Polaris, 56° 35′; long. 109° 37′ F. (chron. 109° 45′·5).

	°	′
Variation, 3 sights, 8.38 A.M.	26	15 0 E.
„ 7 „ 9.30 „	26	59·7
	26	51·4

	°	′
Dip, Gambey No. 1, 9 A.M.	80	36·4

Total Force	Relative	Absolute	W.	
Fox A	1·8464	13·976	(6 0)	
„ C	1·7954	13·589	(0·0)	*rejected*

	Corrected T s	m	X	φ	W.
Magnet No. 30	4·7725	0·4155	2·2805	14·005	(1·0)
„ „ 31	4·9968	0·3841	2·2745	13·936	(1·0)
„ „ 17	5·2313	0·6908	2·2890	14·025	(1·0)
				13·989	(0·3)

Mean by weight, 1·8471, or 13·980.

CCXVIII. I crossed the Portage in the course of the day, horses being kept here by the Hudson's Bay Company to facilitate the *trajet,* and observed at night at the upper or north-west end. Lat. by Polaris, 56° 43′ 41″; long. 109° 52′ 15″ F. (chron. 109° 57′·9). Franklin found here a variation 25° 2′·5 E. in July 1820.

September 17.—Before leaving the station observed.

	°	′
Variation, 7.9 A.M.	28	30·3 E.
„ 7.22 „	28	25·0
„ 7.30 „	28	30 6
Mean . . .	28	28·6

	°	′
Dip, Gambey No. 1, 6 A.M.	80	38·3

CCXIX. Observed again at noon at the *White Earth Portage*, P. Terre Blanche, on the Clear Water River. Lat. 56° 41′ 49″.

CCXX. Observed again at the *Big Rock Portage.* Lat. by account, 56° 43′·5 ; long. 110° 4′ F. (chron. 110° 20′·5).

Variation, 3.43 P.M. . . . . 27° 48′·8

Encamped at Bonne Portage.

CCXXI. *September* 18.—Left camp at 6.25 A.M. Observed at *Cascade Portage.* Lat. by account, 56° 42′·5 ; long. 110° 15′ F. (chron. 110° 23′·6).

	°	′
Variation, 7.38 A.M.	26	44·9
„ 8.14 „	26	54·3

I reached the sulphur springs between 10 and 11 A.M. The temperature of the water about six inches below the surface was 40° F., that of the air being 55°·5, and of the Clear Water River 52°·8.

CCXXII. Leaving the springs at 11.35 A.M., I observed at noon nearly two miles, or about 25 min. in time, below them. Lat. 56° 44′ 54″.

CCXXIII. *September* 19.—Observed about two miles below the mouth of the Red Willow (F.), or Pembina River, a tributary of the Clear Water River. Lat. by Franklin's map, 56° 39′ ; long. 110° 55′ F.

	°	′
Dip, Gambey No. 1, 8.30 A.M.	80	36·2

Total Force	Relative	Absolute	W.	
Fox A	1·8499	14·001	(6·0)	
„ C	1·7992	13·618	(0·0)	*rejected*

	Corrected T s	m	X	φ	W.
Magnet No. 30	4·7822	0·4155	2·2712	13·911	(1·0)
„ 31	5·0201	0·3841	2·2535	13·802	(1·0)
„ 17	5·2529	0·6900	2·2728	13·921	(1·0)
				13·876	(0·3)

Mean by weight, 1·8443, or 13·959.

CCXXIV. Encamped on Pine Island, in the Athabasca, Elk, or Slave River, River La Biche of Franklin. Lat. by Polaris, 57° 0′ 5″ ; long. 111° 20′ F. (by chron. 111° 34′·5″).

CCXXV. *September* 20.—Observed at noon at the mouth of a small stream called *River de la Brai.* Lat. 57° 18′ 33″.

CCXXVI. Reached the *Pierre au Calumet* by Franklin's map. Lat. 57° 24′; long. 111° 35′ F. (by chron. 111° 40′·7).

		°	′
Variation, 5.3 P.M., by a single sight	. .	26	35·1 E.
„ 5.15 „ by six sights	. . .	25	24·9
Mean	. . .	25	43·6

		°	′
Dip, Gambey No. 1, 2.30 P.M. .	. . . .	81	16·8

Total Force	Relative	Absolute	W.	
Fox A	1·9311	14·616	(6·0)	
„ C	**1·8440**	13·957	(0·0)	*rejected*

Needle C, as compared with the last and following station, supports needle A in showing a great increase of force, although the actual value is not to be relied on.

	Corrected T s	m	X	φ	W.
Magnet No. 30	4·8867	0·4155	2·1751	14·347	(1·0)
„ 31	5·1162	0·3841	2·1691	14·308	(1·0)
„ 17	5·3638	0·6898	2·1804	14·382	(1·0)
				14·346	(0·3)

Mean by weight, 1·9249, or 14·559.

This is one of the stations of manifest local disturbance shown by each of the elements and by three independent determinations of force. It probably points to mineral discoveries still to be made. The observation of X would require a dip of 81° 26′·3 to give the same total force as Fox A.

CCXXVII. *September* 21.—Observed at *Point Brulé*, or Burnt Point, on the Athabasca River. Lat. by account, 58° 7′; long. 111° 25′.

		°	′
Dip, Gambey No. 1, 4 P.M.	. . . . .	81	30·6

Total Force	Relative	Absolute	W	
Fox A	1·8345	13·885	(6·0)	
„ C	**1·8184**	13·764	(0·0)	*rejected*

	Corrected T s	m	X	φ	W.
Magnet No. 30	5·0054	0·4155	2·0732	14·043	(1·0)
„ 31	5·2482	0·3841	2·0613	13·962	(1·0)
„ 17	5·4934	0·6896	2·0794	14·085	(1·0)
				14·030	(0·3)

Mean by weight, 1·8409, or 13·933.

CCXXVIII. *September* 22.—Left camp at 4.55 A.M. I could obtain no observations this day. We descended the Embarras

River, a branch of the delta of the Athabasca, and encamped not far from the lake.

September 23, 1843.—Favoured by a total absence of ice, the season being usually open, I crossed Lake Athabasca and reached Fort Chipewyan at midday. Here I was warmly received by the late Mr. Colin Campbell, and resided with him until March 5 following. The arrival created a sensation in the small community, for it was twelve years since any traveller had arrived by canoe from the south; and the self-importance of my *voyageurs*, who had thus happily completed a journey of about 3,600 miles, was conspicuous in their gala attire and gay *chansons* as we approached the landing. They were very shortly sent off to support themselves through the winter at a fishing station on the lake.

CCXXIX. Fort Chipewyan, on Lake Athabasca.

	°	′	″
Latitude as observed, Sept. 26, 1843 . . .	58	42	58
„ „ July 1, 1844 . . .	58	43	9
Franklin's latitude is	58	42	35

For longitude I took the mean of Franklin's determinations of 1820 and 1826, which only differ 40″, *viz.* 111° 18′ 40″, or $7^h\ 25^m\ 15^s$ from Greenwich, and $8^h\ 5^m\ 1^s$ from Göttingen.

Variation:—

			°	′
I.	Sept. 23.	By the first six of twelve azimuths, 3.50 P.M.	28	9·1 E.
II.	„	By the last six, at 3.59 P.M.	27	8·4
			27	38·7

A movement in azimuth of the sun of 2° 26′·6 was followed by a movement of the compass cards of 3° 27′·3, an evident jump at the seventh reading. Having no ground for preference I take the mean.

III. October 16.—The variation was observed with the suspended collimator magnet, at 3.52 P.M. . . . . 28° 30′·8

IV. July 2, 1844.—The variation was again observed with the same magnet at 9.34 A.M. . . . . 29° 52′·0

Mean . . . . . . 28° 45′·8

	°	′
Dip, September 30, 1843, Gambey, No. 1, 9 A.M.	81	37·7
„ „ „ „ „ 2, 11 „	81	37·5
„ February 27, 1844 „ „ 1, 4 P.M.	81	35·4
Mean	81	36·8

Total Force		Relative	Absolute	W.
Fox A, Sept. 25 (1)	.	1·8263	13·823	(5·0)
„ „ (2)	.	1·8366	13·908	(5·0)
„ Oct. 9 .	.	1·8290	13·843	(5·0)
			13·858	(2·5)
By Lloyd B, Sept. 30	.	1·8486	13·986	(1·5)
„ Oct. 6	.	1·8471	13·980	(1·5)
„ „ 10	.	1·8500	14·002	(1·5)
			13·989	(0·45)

Equivalent in relative force 1·8415.

Needle C is rejected for the reasons already given at Station CCX. The values it gave were as follows :—

Total Force	Relative	Absolute	
Sept. 25 . . .	1·7769		
„ 27 . . .	1·7913		
Oct. 7 . . .	1·7841	13·502	*rejected*

The observations of vibration and deflection for the determination of the horizontal force in absolute measure were multiplied at this station, and included three spare magnets, Nos. 20, 23, and 29, which had not heretofore been employed in this way.

			Corrected T_s		m	X	ϕ	W.
Oct. 13, 1843,	Magnet	30	5·0514		0·4177	2·0247	13·921	(1·5)
„	„	„	6·1381	𝔖	0·4169	2·0209	13·879	(1·5)
„	„	31	5·2816		0·3858	2·0301	13·941	(1·5)
„	„	„	6·4017	𝔖	0·3852	2·0269	13·919	(1·5)
„	„	17	5·5724		0·6882	2·0248	13·904	(1·0)
Oct. 14	„	20	4·3373		0·5154	2·0167	13·849	(1·0)
„	„	23	5·2689		0·2064	2·0381	13·996	(1·0)
„	„	29	4·4147		0·1558	2·0291	13·934	(1·0)
March 1, 1844	„	30	5·0328		0·4207	2·0249	13·845	(1·5)
„	„	„	6·1234	𝔖	0·4207	2·0184	13·801	(1·5)
„	„	31	5·3[illegible]40		0·3763	2·0083	13·731	(1·5)
„	„	„	6·4728	𝔖	0·3781	2·0201	13·812	(1·5)
July 2	„	30	5·1507		0·3988	2·0398	13·947	(1·5)
„	„	31	5·4725		0·3568	2·0405	13·952	(1·5)
„	„	17	5·6326		0·6691	2·0378	13·936	(1·0)

We have then—

		°	′	ϕ	W.
By eight determinations of the absolute horizontal force in Oct. 1843	. δ =	81	37·6	13·917	(10·0)
By four, in March 1844 . .	. δ =	81	35·4	13·780	(6·0)
By three, in July 1844 . .	. δ =	81	35·4 [1]	13·946	(4·0)
				13·881	

[1] The dip was not observed in July; I have used the observation of March. The periodical change is very small. At Toronto, by thirty-one years' observations, −1′·2.

And the final results for this station are—

	ϕ	*W.*
By Fox's needle A	13·858	(1·5)
„ Lloyd's needle B	13·989	(0·45)
„ Absolute measure	13·881	(2·00)

The mean of the whole is **13·885**, equivalent to **1·8346** on the relative scale, being a little less than was formerly assigned (**1·838**).

Although the loss of force in Fox's needle C, first unmistakable at Station CCX, makes the succeeding observations with that needle unsuitable for comparison with the base station (Norway House), after September 4, they are not on that account quite devoid of value. The course follows very nearly the isodynamic line of 14·00, and in the deviations on either side of that line we find needle C, as compared with itself from day to day, giving results which differ in *sign* at one station only (CCXV) from those by needle A, and agree with two exceptions with the changes in the total force assigned independently from the observations of horizontal vibration.

Table XVIII.

Comparison of Total Force by Three Methods of Determination, for the last Eight Stations before reaching Athabasca.

Station	Fox A ϕ_1	Diff.	Fox C ϕ_2	Diff.	Vibrations ϕ_3	Diff.
CCX.	14·056		13·679		14·038	
		−·012		−·070		−·055
CCXI.	14·044		13·609		13·983	
		−·008		−·080		+·010
CCXII.	14·036		13·529		13·993	
		−·200		+·111		−·071
CCXV.	13·836		13·640		13·922	
		+·030		−·051		+·067
CCXVII.	13·976		13·589		13·989	
		+·025		+·029		−·013
CCXXIII.	14·001		13·618		13·876	
		+·615		+·339		+·470
CCXXVI.	14·616		13·957		14·346	
		−·731		−·193		−·316
CCXXVII.	13·885		13·764		14·030	
		−·027		−·262		−·149
CCXXIX.	13·858		13·502		13·881	

SECTION V.

FROM LAKE CHIPEWYAN, ON LAKE ATHABASCA, BY WAY OF PEACE RIVER TO DUNVEGAN. THENCE BY LESSER SLAVE LAKE TO EDMONTON, ON THE SASKATCHEWAN, AND FROM THENCE TO CUMBERLAND HOUSE, ON THE SAME RIVER.

About 1,340 *miles.*

Observations north of Peace River are reserved for the last Section.

Preliminary Remarks.—The Peace River at the time of my visit in 1844 was almost unknown, except to a few officers of the Hudson's Bay Company. No scientific traveller had ascended it since Mackenzie in 1789, whose narrative gives but little precise geographical information. In extending, therefore, the observations of my magnetic survey to the westward, I laid myself out particularly to map down the course of the river, taking very detailed notes from hour to hour. These notes were all lost, with my journals, in travelling through the United States in 1846, and I can only now reproduce the observations for latitude and longitude, with a few particulars gleaned from letters and other sources. About 150 miles of the course of the river were, however, laid down from my Field Sketches. The opportunities for observation, without much loss of time, which are afforded by portages on most of the lines of navigation, are wanting on this stream; the portage at the Falls (Station CCXXXIX) is the only one in 600 miles, and as the lateness of the season made it of vital importance to press on, my halts were not so frequent as heretofore. This accounts for the stations of magnetic observation being fewer in number and further apart than usual.

July 4, 1844.—I left Fort Chipewyan (CCXXIX) in the forenoon.

CCXXX. *July* 5.—Entered Peace River, and observed at noon. Lat. 58° 55′ 25″.

CCXXXI. Observed in the afternoon at *Point Providence.* Lat. 58° 58′; long. 112° 10′.

	°	′
Variation by collimator, 3 11 P.M.	30	35 E.
Dip, by Gambey No. 1	81	46·1

CCXXXII. *July* 6.—I was at mid-day among the *Gypsum Islands.* Either from want of a landing-place or from the sun being clouded, an observation for latitude was not taken until 50 minutes past noon, and the result can only be regarded as an approximation; it was 59° 14′ 51″. It places the course of the stream here about ten miles more to the north than it is laid down in the maps.

CCXXXIII. Observed for time P.M. Lat. by account, 59° 15′; long. 3–4 P.M., 112° 44′·5.

CCXXXIV. *July* 7.—Observed in lat. by account, 58° 58′; long. 112° 56′·1.

	°	′
Variation by collimator, 7.19 A.M.	32	24 E.
Dip, by Gambey No. 1	81	36·9

CCXXXV. Observed at noon. Lat. 58° 53′ 23″.

CCXXXVI. *July* 8.—Observed. Lat. by account, 58° 44′; long. at 7.22 A.M., 113° 27′.

CCXXXVI *b.* Observed at noon. Lat. 58° 38′.

CCXXXVII. *July* 9.—Observed on *Poplar Island.* Lat. by account, 58° 39′; long. 8.4 A.M., 114° 10′·7.

	°	′
Variation by collimator, 9.30 A.M.	26	29·8 E.
Dip, by Gambey No. 1	81	4·8

CCXXXVIII. Observed at noon. Lat. 58° 35′ 34″.

CCXXXIX. *July* 10.—Reached the *Falls of Peace River,* the only portage on its lower course. Lat. by account, 58° 24′·2; long. 8.13 A.M., 114° 51′·1.

	°	′
Variation by collimator, 10.38 A.M.	30	22 E.
Dip, by Gambey No. 1	80	50·8

CCXL. Observed at noon, about five miles westward of the Falls. Lat. 58° 22′ 11″. (The Fall is 8 feet.)

CCXLI. *July* 11.—Observed at noon, nearly opposite Fort Vermilion. Lat. 58° 23′ 19″, and arrived soon afterwards at the Fort.

CCXLII. FORT VERMILION, or Fort Lefroy. Lat. observed July 12, 58° 24′ 28″; long. 115° 58′·6.

	°	′
Variation by collimator, 6.31 P.M. of the 11th .	32	40 E.
Dip, by Gambey No. 1	80	48·4
,, ,, No. 2	80	47·6

Total Force	Relative	Absolute	*W.*
By Fox A, July 12 . .	1·8642	14·109	(5·0)
,, C ,, . .	1·8365	13·900	(5·0)
.	1·8502	14·004	(1·0)

Horizontal force in absolute measure :—

	Corrected T	*m*	*X*	*φ*	*W.*
	s				
Magnet 30	4·9000	0·4601	2·2443	14·037	(1·5)
,, 31	5·1890	0·3592	2·2590	14·129	(1·5)
,, 17	5·3771	0·6678	2·2412	14·018	(1·5)
			2·2482	14·061	(4·5)

The mean of the whole is 14·022, equivalent to 1·8526.[1]

CCXLIII. *July* 13.—Left Fort Vermilion in the forenoon. Observed at noon about ten miles to the westward. Lat. 58° 21′ 58″.

I encamped this night a little below the mouth of a small stream which flows into Peace River from the west, the name of which I did not ascertain.

CCXLIV. *July* 14.—Observed. Lat. by account, 58° 14′·2; long. 7.50 A.M., 116° 32′·9.

[1] The relative force formerly assigned was 1·811, the observations with Fox A being referred to Toronto as base, which is inadmissible, and those with Fox C omitted altogether. They are here referred to Fort Chipewyan (CCXXIX), with base value 1·8346.

CCXLV. Observed at noon, about four miles above the Winter Portage road, and about two miles above a small stream, which flows in from the east. Lat. 58° 5′ 51″.

CCXLVI. *July* 15.—Observed on an island opposite *Baril River*, a stream which flows in from the east. Lat. by account, 57° 57′; long. 7.41 A.M., 117° 4′·7.

	°	′	
Variation by collimator, 8.22 A.M.	29	56	E.
Dip, by Gambey No. 1	80	0·7	

CCXLVII. Observed at noon. Lat. 57° 49′ 46″.

Encamped about twelve miles above Iroquois River, and a little above Wolverine Point.

CCXLVIII. *July* 16.—Observed. Lat. by account, 57° 39′; long. 7.51 A.M., 116° 55′.

CCXLIX. Observed at noon. Lat. 57° 32′ 28″.

CCL. *July* 17.—Observed A.M. Lat. by account, 57° 19′; long. 7.57 A.M., 117° 1′·7.

	°	′	
Variation by collimator, 8.39 A.M.	28	53	E.
Dip, by Gambey No. 1	79	27	

CCLI. Observed at noon. Lat. 57° 16′ 40″.

CCLII. *July* 18.—Observed. Lat. by account, 57° 4′; long. 7.52 A.M., 117° 5′·1.

I have here noted that the formation was shale, visible about fifty feet above the river, the base being hidden by *débris*; above the shale was about thirty feet of compact gravel, containing much iron, and cemented into a conglomerate at the top. A bed of limestone one to two feet thick was in some places visible between the shale and the gravel.

I brought away a small quantity of fossil shells, which were identified by the late General Portlock, R.E., as *Terebratula reticularis*, or *Delthyris reticularis*, a Devonian and Upper Silurian fossil, of which I also brought specimens from Mackenzie's River.

CCLIII. Same day. Observed at noon. Lat. 56° 58′ 37″.

CCLIV. *July* 19.—Observed opposite the *River Cadotte.* Lat. by account, 56° 47′; long. 8.50 A.M., 117° 1′·7.

	°	′
Variation by collimator, 9.17 A.M.	27	3 E.
Dip by Gambey No. 1	79	20·7

CCLV. Observed at noon. Lat. 56° 41′ 46″.

I passed the spot known as the Palisades this day; a vertical cliff of sandstone imperfectly stratified towards the top, but very compact below, and rent with vertical fissures; the base for a height of sixteen feet is hidden by *débris*, but it apparently overlies the shale.

CCLVI. *July* 20.—Observed lat. by account, 56° 27′; long. 8.12 A.M., 117° 2′·7.

CCLVII. Observed at noon. Lat. 56° 19′ 52″.

My encampment this night must have been near the Forks at the mouth of Smoky River, which, however, was passed without observation.

CCLVIII. *July* 21.—Observed at noon. Lat. 55° 57′ 32″.

CCLIX. *July* 22.—Observed at noon. Lat. 55° 52′ 51″, and reached Fort Dunvegan before 4 P.M.

CCLX. FORT DUNVEGAN.

I am unable to find the observation upon which the lat., assigned in 1846, is founded, and can only repeat it—viz., lat. 55° 55′ 36″; long. by chronometer, 118° 28′ 31″. By two sets of lunar distances moon from sun west of her, 118° 40′ 45″.[1] The most recent maps published by authority differ much in the position they assign to this fort. In the only map extant in 1844, it was placed by Arrowsmith in 117° 30′; in the map attached to the Geological Survey of 1875–6 it is placed in 118° 52′; in the map of the Canada Pacific Railway, accompanying the Progress Report of 1876, in 118° 50′; in the map of Manitoba, dated March 1880, again in 117° 30′; lastly, in a map dated 1882, in 118° 26′. My chronometer longitude is dependent upon the longitude assigned to the Fort on Lesser Slave Lake, namely, 116°, and Fort Chipewyan 111° 18′ 42″; but the lunars agree pretty well, and confirm it

[1] Formerly published 118° 19′. The observations have been recalculated for me by Mr. Coles, of the Royal Geographical Society.

as against the more easterly places assigned, and until corrected by better observation I adopt 118° 35′.

		°	′
Variation by collimator, July 23, 10.5 A.M.	.	27	9 E.
„ „ „ 25, 5.49 P.M.	.	27	24

		°	′
Dip, July 22, P.M., Gambey No. 1	. . .	78	45·7
„ „ „ „ „ 2	. . .	78	46·8
		78	46·2

Total Force	Relative	Absolute	W.
By Fox A	1·8565	14·048	(5·0)
„ C	1·8450	13·964	(5·0)
	1·8507	14·006	(1·0)

Horizontal force in absolute measure:—

	Corrected T	m	X	φ	W.
	s				
Magnet No. 30	4·4557	0·3993	2·7224	13·979	(1·5)
„ „ 31	4·7671	0·3528	2·7254	13·994	(1·5)
„ „ 17	4·8589	0·6727	2·7252	13·993	(1·5)
			2·7243	13·989	(0·45)

The mean of the whole is 14·000, in relative measure 1·8498.[1]

I observed the Göttingen Term day of July 23–4 at this fort. It presented no feature of interest.

July 26.—Accompanied by Mr. Dyke Bouchier, a young clerk of the Hudson's Bay Company with whom I had passed the winter at Lake Athabasca, I left Fort Dunvegan this day for Lesser Slave Lake, by land. The instruments were carried by pack-horses, and the loads requiring to be carefully made up, they were not unpacked at ordinary halts. The weather was most unfavourable for observations, and I am unable in consequence to lay down my track, but a few points are determined. The distance is about 100 miles by the 'Kristenaux War Path' of old maps, which passes south of the great morasses round the Stinking Lakes.

CCLXI. *July* 27.—Observed for longitude at 8.44 A.M. Having failed of an observation for latitude at noon, the result is only approximative. Lat. assumed 55° 50′; long. 118° 33′·5.

CCLXII. *July* 28.—Observed for longitude where the trail passes Burnt River 117° 39′ 48″; lat. by account 55° 51′.

[1] Formerly given as 1·809 (*see* note to Station CCXLII).

CCLXIII. Observed at noon at the River de Prairie, 55° 49′ 3″.

July 29.—Crossed Smoky River, or River de Boucane.

July 30.—Observed the temperature of boiling water to obtain the elevation of the region about fifteen miles west of it. Crossed the Rivière qui barre (le chemin).[1]

July 31.—Sent on the baggage and visited 'The Smokes' or sulphur springs on Smoky River.

August 1.—Guided by some Indians and accompanied by Mr. Bouchier, I visited the Crow Lakes and the Stinking Lake, the water of which was found so saturated with sulphuretted hydrogen that even when boiled it was unfit for making tea. We got back to camp at a very late hour.

August 2.—Arrived at the Fort on Lesser Slave Lake unexpectedly, no notification of my visit having reached the officer in charge.

CCLXIV. *August* 3.—At the Fort LESSER SLAVE LAKE. Lat. by observation at noon, 2nd, 55° 32′ 39″; 4th, 55° 32′ 41″.

Longitude by lunar distances.

		°	′	″		
Aug. 3.	(1)	115	48	0 W.	☽	from *a* Aquilæ W.
	(2)	116	2	30	☽	from Saturn W.
	(3)	116	9	21	☽	from *a* Aquilæ W.
Aug. 4.	(4)	115	58	45	☽	from Sun E.
	(5)	116	0	6	☽	from Sun E.
	(6)	116	1	0	☽	from Sun E.
Mean .		115	59	57 W. or $7^h\ 44^m$.		

The result was formerly published as 115° 53′ 30″. I am indebted to Mr. J. Coles of the Royal Geographical Society for going over and recalculating the observations.

	°	′
Variation by collimator, 5.37 P.M., 3rd .	26	52·5 E.
Dip, by Gambey No. 1	78	36·2
„ „ „ 2	78	41·8
	78	39·0

Horizontal force in absolute measure *August* 5, by vibration only.

[1] This was frequently done, with the general result that the prairie in this region must be about 1,800 feet above the sea; but the weather was very unsettled all the time.

	Corrected T s	m	X	φ	W.
Magnet No. 30	4·4449	0·3985	2·7412	13·929	(1·0)
„ 31	4·7706	0·3517	2·7302	13·873	(1·0)
„ 17	4·8741	0·6700	2·7180	13·814	(1·0)
			2·7298	13·872	(0·30)

In relative value 1·8329.

I fortunately found a canoe at the fort and re-embarked on the 5th.

CCLXV. Encamped on Cranberry Point, a spot on the north side of the lake which I cannot identify on the maps. Lat. by Polaris, 55° 29′ 32″; long. by observation of *a* Aquilæ, 115° 9′ 45″.

CCLXVI. *August* 6.—Crossed the lake and observed at Swan Point, or Point Dejala, on the south side. The passage was made memorable by our shooting a moose deer, which had been driven by some Indians into the water. Lat. 55° 26′; long., 8.27 A.M., 115° 3′·1.

	°	′
Variation by collimator, 10 A.M.	26	19
Dip, Gambey No. 1	78	29·9

CCLXVII. Observed on the same side at noon six or seven miles further west. Lat. 55° 25′ 19″.

CCLXVIII. *August* 7.—Observed at noon on Lesser Slave River, the stream which empties the lake. Lat. 55° 15′ 7″.

CCLXIX. Observed again at the Forks of the Athabasca, where the same stream falls into the Elk, or Athabasca River. Lat. by account, 55° 13′; long., 3.57 P.M., 113° 53′ 15″.

	°	′
Variation by collimator, 4.44 P.M.	23	28 E.
Dip, Gambey No. 1.	78	55·2

CCLXX. *August* 8.—Observed for longitude on the Elk, or Athabasca River. Lat. by account, 55° 3′; long., 7.42 A.M., 114° 0′·2.

CCLXXI. Observed at noon. Lat. 54° 56′ 18″.

CCLXXII. Encamped opposite the Pembina River. Lat. by Polaris, 54° 48′ 31″.

CCLXXIII. *August* 9.—Observed again on the Athabasca River. Lat. by account, 54° 43′; long., 8.16 P.M., 114° 0′·2.

	°	′
Variation by collimator, 9.10 A.M. . . .	26	29·1 E.
Dip, Gambey No. 1	78	34·1

CCLXXIV. Observed at noon. Lat. 54° 33′ 27″.

CCLXXV. Observed at encampment. Lat. by Polaris, 54° 25′·5; long. by Arcturus, 114° 11′.

CCLXXVI. *August* 10.—Observed at noon. Lat. 54° 20′ 19″, and reached Fort Assiniboine soon afterwards.

CCLXXVII. *August* 11.—At Fort Assiniboine. Lat. by observation at noon, 54° 21′ 42″; long. 114° 28′ 24″. By Polaris, 54° 21′ 7″.

	°	′
Variation by collimator, 7.2 A.M., of 12th .	24	39 E.
Dip, Gambey No. 1	78	16·9
" " " 2	78	13·5
	78	15·2

August 12.—Accompanied by a Wesleyan missionary who availed himself of the escort to Edmonton, I crossed the Elk River in the canoe, horses being swum over, and started for that post.

CCLXXVIII. *August* 13.—Encamped at *Paddle River*. Lat. by Polaris, 54° 5′ 44″; long. by Arcturus, 114° 3′·6.

CCLXXIX. *August* 14.—Observed at the crossing of the *Pembine River*, which we swam, as we did some smaller streams, but carried over the baggage on a raft. Lat. by account, 54° 3′·2; long. 114° 0′·2.

	°	′
Variation by collimator, 9.42 A.M.	22	23 E.
Dip by Gambey No. 1	77	54

August 15.—No observations recorded. It rained nearly all the time of this journey, so that opportunity of observations was very much wanting.[1]

August 16.—I reached Edmonton on the Saskatchewan, in the forenoon.

[1] Letter to Lieut.-Colonel Sabine.

CCLXXX. Edmonton.—This station is about nineteen miles N. by W. from the intended station of the same name on the Canada Pacific Railway. Its geographical position was fixed in 1879 with great precision by Mr. W. F. King, the surveyor in charge of the astronomical section of the standard survey of the north-west territory. Mr. King assigns lat. 53° 31′ 54″; long. 113° 30′ 19″, or 7^h 34^m $1^s{\cdot}3$ W.

I had three observations of latitude:—

	°	′	″
August 16	53	32	2
„ 17	53	31	18
„ 19	53	31	56

The second of these was interrupted for 25^m at the critical time of noon by the sun being too indistinct for observation. Giving it half weight, the resulting latitude for Edmonton is 53° 31′ 51″, or only 3″ less than the recent determination.

The longitude given in 1846 was 112° 52′, which proves to be considerably in error. It was based entirely on the longitude of Carlton House determined by Franklin's expedition, for my chronometer series from Athabasca was, unfortunately, broken by the stoppage of my only chronometer on August 15. Carlton House (*see* station CCLXXXIX) is now placed 19′ 20″, or 1^m $17^s{\cdot}3$, of time west of Franklin's position, and by the error of rate involved in the latter I was led to place Edmonton also far to the east of its true position. But the stations between Edmonton and Athabasca appear to be rightly placed. I find Paddle River at the crossing (CCLXXVIII) 33′ 15″ west of Edmonton, and this must be very near the truth. It is to be hoped, however, that the survey will ere long be extended to Lesser Slave Lake and Peace River.[1]

	°	′
Variation by collimator, 7.31 A.M., 16th	23	47[2]
Dip by Gambey No. 1, Aug. 17	77	53·4
„ „ „ 2, „	77	55·1
	77	54·2

[1] Franklin's longitude of Carlton House was 106° 12′ 41″. It has retained that position on the maps until recently; Mr. King, of the Canada Survey Department, has, however, found it to be 106° 32′, consequently all longitudes formerly referred to that station have required correction (*see* CCLXXXV).

[2] Formerly published 24° 16′ E. by a clerical error since detected.

Total Force	Relative	Absolute	W.
Fox A	1·8558	14·046	(5·0)
„ C	1·8391	13·919	(5·0)
	1·8474 [1]	13·982	(1·0)

Horizontal force in absolute measure:—

	Corrected T s	m	X	φ	W.
Magnet No. 30	4·2948	0·3978	2·9411	14·040	(1·5)
„ „ 31	4·5935	0·3507	2·9527	14·095	(1·5)
„ „ 17	4·6876	0·6702	2·9383	14·027	(1·5)
			2·9440	14·054	(0·45)

The mean of the whole is 14·000, equivalent to 1·8498 on the relative scale.

I have pointed out on p. 35 that the force formerly assigned to Edmonton, viz., 1·809, or 13·69, was incorrect, the absolute determinations having been overlooked by General Sabine. This station, being geographically the nearest to the district surveyed magnetically by Captain Haig in British Columbia, in 1858–60, and not more than 220 miles distant from the line of 13·50, as laid down by him, is within the range of direct comparison with his independent results. We find that, taking the increase of force to be at the rate of 0·10 for 77·66 miles measured on the normal to that line (Haig), the force at Edmonton would have been 13·80 in 1860; but it was greater in 1844 than it was in 1860, as we may infer from the fact of its having decreased in that interval at Toronto, which is on nearly the same isodynamic line. Assuming the rate of secular change to have been alike in both places, it would have been 13·897 at Edmonton in 1844 by Captain Haig's observations, and a slightly more rapid rate of secular change would produce a close agreement with the above result of 14·000.

I left Edmonton in a boat provided by Mr. Rowand, the chief factor in charge, with the intention, by his advice, of dropping down the river by night, and thus escape the observation of the Blackfeet, and other warlike tribes of the plains who were at that time ranging the country. We were provided with a few muskets for defence if necessary.

CCLXXXI. *August* 20.—I landed in a secluded spot on the north or left bank of the river, for breakfast, and observed. The locality must have been near the present Victoria Mission Station. Lat. by account, 54° 4′·5; long. 112° 19′·5.

[1] Formerly published 1·809 (*see* for explanation Station CCXLII).

		°	′
Variation by collimator, 9.20 A.M	. . . .	23	55 E.
" " " 9.33 "	. . . .	24	56
		24	25 E.[1]
Dip by Gambey	. . . .	78	5·2

Horizontal force in absolute measure by vibration only:—

	Corrected T (s)	m	X	φ	W.
Magnet No. 30	4·3747	0·3979	2·8341	13·729	(1·0)
" " 31	4·6908	0·3515	2·8255	13·687	(1·0)
" " 17	4·7792	0 6700	2·8276	13·698	(1·0)
			2·8291	13·705	(0·3)

The equivalent in relative force is 1·8107.

CCLXXXII. Observed at noon, about six miles lower down. Lat. 54° 3′ 30″.

CCLXXXIII. *August* 21.—Landed again on the north side of the river, a little beyond Moose Hill Creek. Having failed to get an observation of the sun at noon I take the lat. from the latest map, 53° 50′; long. 110° 59′.

		°	′
Variation by collimator, 8^h 8^m A.M.	. . .	24	26·6 E.
Dip, by Gambey No. 1.	. . . . .	78	33·5

Horizontal force in absolute measure:—

	Corrected T (s)	m	X	φ	W.
Magnet No. 30	4·4348	0·3979	2·7579	13·903	(1·0)
" " 31	4·7706	0·3515	2·7318	13·772	(1·0)
" " 17	4·8472	0·6700	2·7495	13·861	(1·0)
			2·7464	13·812	(0·3)

The equivalent in total force is 1·8249.

I reached Fort Pitt the same evening.

CCLXXXIV. *August* 22.—At Fort Pitt.

Observed lat. by Polaris, 53° 35′ 2″; long. 109° 47′ 10″. Mr. F. W. King has found, for 'a station on the river bank near Fort Pitt,' 53° 34′ 5″; long. 109° 47′ 10″.

		°	′
Variation by collimator, 6.50 A.M.	. . .	23	7·3 E.
" " " 7.57 "	. . .	23	11·2
Dip, A.M., Gambey No. 1	. . . . .	78	43·0
" " " " 2	. . . . .	78	39·1
		78	41·0

[1] The difference between the first and second observation this day was traced to the theodolite, which was out of order. The same remark applies to the observations at Edmonton; for want of any indication which result is correct I take

Horizontal force in absolute measure by vibrations only :—

	Corrected T s	m	X	ϕ	W.
Magnet No. 30	4·4167	0·3979	2·7810	14·169	(1·0)
„ „ 31	4·7334	0·3515	2·7749	14·141	(1·0)
„ „ 17	4·8223	0·6700	2·7773	14·153	(1·0)
			2·7777	14·154	(0·3)

This value is largely in excess of what is due to the position, and, like the next two stations, indicates a great dislocation of the magnetic lines in this region. The equivalent relative force is 1·8700.

The lawless state of the native Indian population of the great plains, even within British territory, at this time, was well exemplified by an incident, of which I saw the effects at Fort Pitt. The Blackfeet were at war with the Crees, and had recently managed to interrupt a small and harmless party of the latter, who were coming to the Fort to trade. They attacked them close to the Fort, and killed two or three, when the people of the Fort made a sally and drove them off. Among those saved was a squaw, who had been shot through the upper part of the body; the wounds were nearly healed, but the poor woman thought that so great a medicine-man could do something for her, and could not be contented until I had covered both wounds with diachylon plaster—a safe application.

CCLXXXV. *August* 23.—The place of observation this day was in the neighbourhood of what are now marked on the maps as Willow Hills. It would appear from the disturbance of the magnetic elements to be of different geological formation from the region recently traversed. Lat. by an observation 39ᵐ late, reduced to the meridian, 53° 0′ 7″; long. 108° 30′ 3″. The latitude formerly given was 53° 7′ by mistake.

	°	′
Variation, 2.40 P.M.	28	24·1 E.
Dip, Gambey No. 1, P.M.	78	28·1

Horizontal force in absolute measure :—

	Corrected T s.	m	X	ϕ	W.
Magnet 30	4·3646	0·3978	2·8480	14·246	(1·0)
„ 31	4·6798	0·3515	2·8388	14·201	(1·0)
„ 17	4·7562	0·6700	2·8551	14·282	(1·0)
			2·8473	14·243	(0·3)

the mean. The instrument was adjusted as far as I could effect it, but 'remained in indifferent order, the axle being slightly bent, and one, if not two, of the verniers standing off the limb.' (*Note* in Observation Book.)

The equivalent in relative force is 1·8819, indicating, like the last station, considerable local effect.

CCLXXXVI. Encamped about seven miles N.W. by W. from Battle River. Lat. by Polaris, 52° 45′ 22″; long. 108° 12′ 0″. The distance and bearing given would place Battleford, at the mouth of the river, in about lat. 52° 42′ 30″; long. 108° 3′ 48″. Mr. W. F. King has found for a hill 10″ south of Battleford and south of Battle River, lat. 52° 42′ 49″; long. 108° 16′ 59″, but it is not stated how this spot is related to the mouth of the river.

CCLXXXVII. *August* 24.—Observed at noon about the elbow. Lat. by a late observation, reduced to the meridian, 52° 21′ 24″; long., by account, 107° 23′.

	°	′
Variation by collimator, 2.30 P.M. . . .	25	21·4 E.
Dip, Gambey No. 1	78	16·6

Horizontal force in absolute measure:—

	Corrected T_s	m	X	ϕ	W.
Magnet 30	4·3520	0·3978	2·8637	14·062	(1·0)
„ 31	4·6534	0·3515	2·8711	14·130	(1·0)
„ 17	4·7525	0·6700	2·8595	14·073	(1·0)
			2·8648	14·088	(0·3)

The equivalent in relative force is 1·8615.

This station, like the two preceding ones, is evidently affected by local causes.

CCLXXXVIII. Observed for time about six miles lower down, as I imagine near Eagle Creek of modern maps. Lat. by account, 52° 21′·4; long. 107° 23′ 4″.

August 25.—Reached Carlton House.

CCLXXXIX. Carlton House.—A part of Franklin's party wintered here in 1820, and I adopted the latitude and longitude given by him. Mr. F. W. King has since (1879) fixed a station near, but apparently two miles to the north of the Fort, at the steamboat landing on the river.

	Franklin, 1820.			King, 1879.		
	°	′	″	°	′	″
Lat.	52	50	47	52	52	37
Long.	106	12	41	106	32	1

The river runs a little east of north here. In the absence of identification of the precise spot I adhere to Franklin's latitude, but adopt Mr. King's longitude, which is followed on the latest Dominion maps.[1]

Lieutenant Blakiston, R.A., passed the winter of 1857–8 at this Fort, and made hourly observations of the declination, which were discussed at great length by General Sabine in connection with other stations in 1860;[2] but with entire absence of any allusion to the observations of the present writer at Lake Athabasca in 1843–4, by which the same periodical laws were established and previously published.

	°	′
Variation by collimator, August 26, 9 A.M. .	22	55 E.
Dip, Gambey No. 1	78	30·2
" " " 2	78	31·2
	78	30·7

Horizontal force in absolute measure:—

	Corrected T (s)	m	X	φ	W.
Magnet 30	4·4542	0·3965	2·7432	13·773	(1·5)
" 31	4·7654	0·3499	2·7499	13·807	(1·5)
" 17	4·8565	0·6700	2·7438	13·749	(0·75)
			2·7438	13·782	(0·37)

The equivalent in relative force is 1·8209.

The observations with Bars 30 and 31 being complete, are allowed double weight. The ratio $\frac{m}{X}$ was not observed for Bar 17.

One of the few adventures that befell me in a journey which was especially laid out for scientific work, and almost excluded sport or excitement of any kind, occurred on the evening of leaving Carlton House, and the country being now peaceably settled and occupied by an industrious agricultural population. I extract from a letter addressed to Lieut. Riddell the account I gave him of it shortly afterwards:—

I had a very pleasant voyage down the Saskatchewan, and met with an adventure which gave me some amusement at the time. The Plain Indians are in a state of warfare, and there is a certain degree of danger in a solitary boat or canoe passing through their country. The travelling war parties are no respecters of persons, and would scalp the illustrious Gauss himself as soon as anybody. By way of defence we carried some

[1] Standard Meridians and Parallels, 1878.

[2] See *Observations made at the Magnetical and Meteorological Observatory at St. Helena*, vol. ii. p. cv.

old muskets, but we arrived at Fort Carlton without danger. We saw a few buffalo and deer, and plenty of wolves, but not one Indian, for they were all away in another direction. A few miles below Carlton the thick woods commence, where danger from the Indians of the plain is usually considered to be at an end. We left our muskets, therefore, with the trader, and went on unarmed excepting the guns carried by myself and the guide. That evening, an hour or so after sunset, as we were pulling quietly down stream, which is there very rapid, we were hailed out of the dusk of the opposite bank, in the Assiniboine or Blackfoot language, by some party which had encamped there, without a fire; this is always a suspicious circumstance with Indians. We made no reply, but kept on, inclining a little to the other shore. Three or four miles lower down, it being then quite dark, we halted to cook our supper. The spot was a thicket on the top of a high bank, as I supposed, an island. While the supper was cooking—it was a beautiful kettle of buffalo humps and tongues—I heard a faint singing noise in the distance, and was wondering what it could be, when it seemed to become louder and nearer, and caught the ears of the men, who, being engaged, had not heard it so soon. Instantly there was a cry—'Les Assiniboines!' 'Les Gros Ventres!' 'Les Pieds-noir!' 'Embarquez, monsieur, embarquez!' and, seizing their kettles, they tumbled down the bank with incredible expedition. I, of course, had to follow them after securing my own, and we pushed off. All this made some noise, and when we reached the middle of the stream and lay on our oars to listen, there was a dead silence for a moment, then a loud outcry as of wolves and dogs and owls hooting. This is so common a stratagem of the Indians, I felt convinced that they proceeded from a party of them. Singularly enough, not far above, without seeing or hearing anything, we had all perceived in the pure night air the smell which proceeds from a large assemblage of horses; but it was too dark to distinguish any objects on the bank. It is rather unusual for the Indians to range so low, but some Assiniboines arrived at Carlton while I was there, and a war party of fifty Blackfeet had left it only a fortnight previously.

We never encamped between Edmonton and Cumberland, but after cooking supper re-embarked and drifted all night with the stream, keeping one man to look out and steer the boat. It was generally beautiful weather, and I enjoyed no part of the voyage more—a boat being far more comfortable than a canoe.

CCXC. *August* 27.—Observed about two and a half miles below the Forks. Lat. by account, 53° 13′; long. 104° 51′ 34″. This station is near Fort à la Corne of the maps, which cannot, I think, have been occupied as a trading post at the time, or I should have halted there. Professor H. Y. Hind inserts variation, 22° 30′ E. for this fort in his Route Map of 1859.

	°	′
Variation by collimator, 4.44 P.M.	24	45 E.
Dip, Gambey No. 1	79	11·2

Horizontal force in absolute measure :—

	Corrected T s	m	X	φ	W.
Magnet 30	4·5560	0·3977	2·6147	13·928	(1·0)
„ 31	4·8791	0·3575	2·6056	13·889	(1·0)
„ 17	4·9668	0·6700	2·6180	13·955	(1·0)
	Mean .	. . .	2·6128	13·924	(0·3)

The equivalent in relative force is 1·8397.

August 28.—No observation.

August 29, 1844.—I arrived again at Cumberland House, Station CLXXXIII, *which see.*

SECTION VI.

FROM FORT GOOD HOPE, ON MACKENZIE'S RIVER, TO FORT CHIPEWYAN, ON LAKE ATHABASCA.

About 900 *miles.*

Preliminary Observations.—My observations in this remote region are few and far between, the conditions of travelling over the greater part of it having been incompatible with field work. Leaving Lake Athabasca on March 4, 1844, I travelled on snow shoes to Fort Resolution, on Great Slave Lake, and thence to Fort Simpson, a distance altogether of 460 miles, the instruments being packed on dog sledges. The whole journey occupied nineteen days. It is needless to say that long observations in the open air are almost a physical impossibility, with the thermometer far below zero. We had mercury frozen at daybreak on March 25. Therm. $-41°$ F. At the same hour, two days previously, it stood at $+33°$, a range of 74°. I reached Fort Simpson on March 26, and remained there engaged in hourly observations until May 25, when the ice on Mackenzie's River broke up, and the boats started almost instantly for Fort Good Hope. The descent of the Mackenzie is made very rapidly, owing to the strength of the current, and the officer in charge, the late Mr. John Maclean, being the same gentleman with whom I had left Montreal the previous year, made only one short halt, which was at Fort Norman. Returning again from Fort Good Hope, we were favoured by a strong northerly wind (accompanied by snow), and again ran the whole distance of 420 miles, with only one halt, which was also at Fort Norman, making both journeys in an unusually short time. I accompanied the same boats, after a short delay, always pushing on with the utmost expedition, on their way to the Great Portage (Station CCXVII), as far as Fort Resolution. Here I obtained a canoe and left them, and from hence to Lake Athabasca, about 240 miles, observations are more numerous.

It is convenient to take the stations in the order of time. I have been unable to find the original entries for latitude and longitude, which are therefore given without revision, as published in 1846.

CCXCI. *May* 27.—Observed latitude on Mackenzie's River, 64° 7′ 40″.

CCXCII. *May* 29.—Observed latitude at the Rapide sans Sault, 65° 48′.

CCXCIII. *May* 30, 1844.—Fort Good Hope, Mackenzie's River. Lat. by T. Simpson, 1837, 66° 16′; long. 128° 31′.

This post was in Franklin's time about 120 miles lower down, in lat. 67° 28′. It was subsequently moved to Upper Manitou Island, and being swept away from that spot by a flood in 1836, was rebuilt on the mainland opposite that island, where Simpson found it. It was at the same place in 1844. The weather was cloudy, and I was unable to make any observation in my brief visit, excepting one imperfect glimpse of the sun, whence the approximate variation at 8.24 A.M., 42° 26′ E.

By the general testimony of all the recorded observations towards the mouth of the Mackenzie this value is about 2° too low.

		°	′
Dip, May 29, 10.40 P.M., Gambey No. 1	. .	82	55·8
,, ,, ,, 2	. .	82	56·1
		82	55·9

Horizontal force in absolute measure :—

	Corrected T s	m	X	φ	W.
Magnet 30 (1)	6·8206 𝔖	0·4090	1·6729	13·595	(0·5)
,, ,, (2)	5·6013	0·4101	1 6751	13·614	(1·5)
,, 31 (1)	7·2323 𝔖	0·3641	1·6805	13·656	(1·5)
,, ,, (2)	5·9763	0·3641	1·6805	13·656	(1·5)
,, 17 ,,	6·1109	0·6775	1·7103	13·899	(1·0)
	Mean .	. .	1·6918	13·681	(0·60)

Equivalent in relative force to 1·8072.

This observation was made about midnight, the twilight, although the sky was completely clouded over, being nearly as light as day. There was no appearance of disturbance. The vibration of No. 30 was imperfect, owing to the suspension silk breaking; the values given the first line are deduced from the angles of deflection, and the result weighted accordingly.

About this time it occurred to me that the mean angle of deflection of the suspended magnet in Lloyd's induction magnetometer, when it is acted upon by the magnetism induced in a soft iron bar at a constant distance, must vary as the inducing force, or as some function of the total force at the spot. In reality, as the force which resists deflection, viz. the horizontal component, is also a function of the total force at the spot, the observation taken alone does not contain the elements of any solution of the question proposed, which was to determine by a comparison of the angles of deflection the relative force at any two places of observation, nor does the vertical component itself differ much in amount within the limits of the present survey, although the angles of deflection range from 24° to 58° 35′. Since, however, the observation is one which had never before been made, and the experience may have some useful application, I have collected the results in the introduction.

At this station the suspended magnet of the induction inclinometer was deflected by the induced magnetism of the soft iron bar, 58° 35′.

CCXCIV. *May* 28 and *June* 2.—FORT NORMAN.

This fort was in 1844 on the west side of the river. It has, I understand, been since moved to the east side. Lat. by Franklin, 64° 40′ 38″; long. 124° 44′ 47″ W, Table V, but given in the text (p. 18) as 124° 53′ 22″. The former is probably his final value.

	° ′
Dip, May 28, Gambey No. 1	82 34·3

I landed at this establishment in descending the river and again on my return, on both occasions for a few hours only, and under circumstances of weather unfavourable to observation. There was only time on the first occasion to observe the angles of deflection with Magnet 30, giving the ratio $\frac{m}{X}$. The vibration of the same Bar, to give the product mX, had to be postponed until my return on June 2; the data are, therefore, more imperfect at this station than at the others. I subjoin the independent values of X:—

	Corrected T s	m	X	ϕ	W.
May 28. Magnet 30	—	0·4091	1·7525	13·555	(0·75)
June 2. ,, 30	5·4832	0·4091	1·7483	13·522	(0·75)
,, ,, ,, 31	5·8403	0·3616	1·7676	13·672	(1·5)
,, ,, ,, 17	5·9717	0·6778	1·7902	13·847	(0·75)
			1·7652	13·653	(0·37)

Equivalent in relative force to 1·8041.

Taking separately all the data for a comparison of this station with Fort Simpson, we have the ratio of the horizontal component as follows :—

By deflection angles, Magnet No. 30	0·8940
" " " " " 31	0·9134
By times of vibration, Magnet No. 30	0·8945
" " " " " 31	0·8947
" " " " " 17	0·9120
Mean	0·9017

Taking the absolute horizontal force at Fort Simpson as 1·9533, this gives for Fort Norman 1·7608, differing little from the absolute value (1·7652) determined above.

The suspended magnet of the induction inclinometer was deflected by the induced magnetism of the soft iron bar, 55° 49′.

I had a rare opportunity in this neighbourhood of ascertaining the depth of the permanently frozen soil ; a large landslip had very recently occurred near the Gros Cap, in or near lat. 64° 20′, where the cliff was 180 feet high. I estimated the area which had fallen at five acres. It left a clear, sharply-cut perpendicular section of alluvial soil, which was still in a frozen state to a depth of forty-five feet, the limit being very well shown by a change of colour, and by the water trickling out along the line of junction. The summer thaw does not penetrate beyond one foot in sheltered places, as in the woods, and two feet in cultivated ground, of which there was a little round the fort, producing barley and potatoes. The contrast this affords to the depth of at least 382 feet, said to have been ascertained near Yakutsk, in Siberia, is very remarkable—the latter place being 2° more distant from the pole. Erman, indeed, calculates the total thickness of permanently frozen soil in that locality to be as much as 630· feet.[1]

CCXCV. Fort Simpson.

Lat. observed, 61° 51′ 42″ ; by T. Simpson, 1837, 61° 51′ 25″ ; long. by Simpson from a number of lunar distances, 121° 25′ 15″ = $8^h\ 5^m\ 41^s$ W., which is about 8′ E. of the position assigned by Franklin.

			°	′
Variation by collimator, March 30,	7.58 A.M. .	37	52 E
" " " "	9.13 " .	38	43
" " " "	3.46 P.M. .	37	28
" " " "	4.56 " .	38	2
" " May 8,	9.0 A.M. .	37	57
Mean	. . . .	38	0·4 E.

[1] Erman's *Travels in Siberia*, ii. p. 367, Cooley's translation, 1848.

		°	′
Dip, March 28, 4-5 P.M., Gambey No. 1	. .	81	53·8
„ May 10, 11 A.M., „ „	. .	**81**	**41·5**[1]
„ „ „ 12 „ „ „ 2	. .	81	50·7
Mean	. . . .	81	52·2

Absolute horizontal force :—

	Corrected T s	m	X	φ	W.
May 2, No. 30	6·3133	0·4115	1·9365	13·693[2]	(2·0)
„ „ „	5·1393	0·4165	1·9612	13·868[2]	(2·0)
„ „ 31	6·6867	0·3679	1·9456	13·758[2]	(2·0)
„ „ „	5·4691	0·3721	1·9664	13·905[2]	(2·0)
„ „ 17	5·6751	0·6858	1·9592	13·854	(1·0)
			1·9532	13·811	(0·9)
June 12, No. 30	5·2323	0·4019	1·9545	13·821	(1·5)
„ „ 31	5·5993	0·3587	1·9428	13·738	(1·5)
„ „ 17	5·7305	0·6738	1·9556	13·822	(1·0)
„ „ 20	4·6155	0·4655	1·9716	13·938	(1·0)
„ „ 23	5·5003	0·2003	1·9475	13·771	(1·0)
			1·9534	13·803	(0·6)

The mean of the whole is 13·808, equivalent to 1·8244.

I left *Fort Simpson* on June 15, 1844.

CCXCVI. *June* 16.—Observed at noon on the river below an old fort. Lat. 61° 29′·5. The Mackenzie is here flowing nearly due west. Long. from Franklin's map about 120° 20′.

CCXCVII. *June* 17.—Observed at *Burnt Point*, an angle in the river west of the Yellow Knife River. Lat. by account, 61° 10′; long. 119° 9′.

		°	′
Variation by collimator, 9.20 A.M.	. . . .	36	4 E.

CCXCVIII. Observed at noon at Yellow Knife River. Lat. 61° 12′·3.

CCXCIX. *June* 18.—Observed at *Sandy Point*, a promontory of Little Lake, which is merely an expansion of the river. Lat. by account, 61° 20′; long. 118°.

		°	′
Variation, 9.58 A.M.	. . . .	38	5 E.

CCC. Observed at noon on *Little Lake*. Lat. 61° 25′·7.

[1] Rejected. A tinned iron inkstand had been left on the stand too near the needle.

[2] Three distances of deflection employed.

CCCI. *June* 19.—Observed A.M., in lat. by account, 61° 25′; long. 117° 31′.

	°	′
Variation by collimator, 9.17 A.M.	36	7 E.

CCCII. Observed at noon. Lat. 61° 19′.

CCCIII. *June* 20.—Observed on the mainland at a *Fishing Station* opposite the north-west end of Big Island, which bore E. 22° N. Lat. 61° 11′·7; long. 116° 38′.

	°	′
Variation by collimator, 6.2 A.M.	35	28 E.
Dip (observed March 18)	82	8·7

Horizontal force in absolute measure, by angles of deflection only:—

	u		m	X	ϕ	w.
Magnet 30	23°	0′·3 [1]	0·4002	1·8939	13·859	(1·0)
„ 31	20	32·4	0·3592	1·8877	13·813	(1·0)
				1·8908	13·836	(0·2)

CCCIV. Observed at noon opposite the eastern extremity of the same island, which is the entrance of the river. Lat. 61° 7′·7.

CCCV. *June* 21.—Observed at *Hay River*, on the south side of GREAT SLAVE LAKE, the present site of the Roman Catholic Mission of St. Anne. Lat. 60° 48′; long. 115° 18′.

	°	′
Variation by collimator, 7 A.M.	35	56 E.

CCCVI. Observed at noon on the lake near Hay River. Lat. 60° 49′.

CCCVII. *June* 22.—At FORT RESOLUTION, Great Slave Lake. Lat. by my observation, 61° 10′ 42″; Franklin, 1825, 61° 10′ 26″; long. Franklin, 113° 45′; T. Simpson, 1836, 113′ 48′.

	°	′
Variation by collimator, 10.20 A.M., 23rd. .	37	12·5 E.
Dip, A.M., 22nd, Gambey No. 1	82	43·5
„ „ „ „ „ 2	82	45·4

[1] These angles may be compared with the following observed before and after:—

	Bar 30		Bar 31	
	°	′	°	′
Fort Simpson	23	6·5	20	27·6
„ Resolution	24	46·9	22	1·0

Horizontal force in absolute measure :—

		Corrected T_s	m	X	ϕ	W.
June 22.	Magnet 30	5·5320	0·3998	1·7619	13·942	(1·5)
,,	,, 31	5·8714	0·3585	1·7647	13·964	(1·5)
,,	,, 17	6·0479	0·6700	1·7643	13·961	(1·5)
				1·7636	13·956	(0·45)

Equivalent in relative value to 1·8439.

June 23.—I left Fort Resolution in a canoe provided for me by Mr. McMurray, and made for the mouth of Buffalo Creek, about twelve miles S. by W. of the fort. This creek is a small stream flowing into the lake, and is navigable by canoe for nearly fifty miles, when there comes a long portage into Slave River, called the Portage de Grande Détour. It cuts off about thirty miles of the latter river. I had previously travelled by it on snow shoes, in March. The transformation produced by the advance of the summer was very striking.

CCCVIII. *June* 24.—Observed lat. at noon, 60° 54′·3.

CCCIX. *June* 25.—Observed for time, A.M. Lat. by account, 60° 34′; long. 113° 12′·5.

CCCX. Observed at noon. Lat. 60° 29′·7.

Reached the Portage de Grande Détour. Lat. 60° 22′; long. 113°.

	°	′
Observed variation by collimator, 5.58 P.M. .	35	15 E.
Dip, Gambey No 1	82	33·6

In passing this portage the men were attacked by a bear, which the guide, Pierre Blondin, was fortunate enough to shoot. Encamped here.

CCCXI. *June* 26.—Observed at noon at the first small lake in the portage. Lat. 60° 20′·6.

CCCXII. *June* 27.—Reached Salt River A.M., and observed for time. Lat. 60° 6′; long. 112° 15′.

CCCXIII. Observed at noon. Lat. 60° 2′·2.

CCCXIV. Observed at P.M. Pelican Portage. Lat. 59° 58′; long. 111° 51′.

	°	′
Variation by collimator, 6.24 P.M.	36	15 E.
Dip, Gambey No. 1	82	26·8

This station is about ninety-five miles north of Fort Chipewyan (Station CCXXIX), where I arrived again, without further observation, on June 30, 1844.

END OF THE DIARY.

POSTSCRIPT.

Since the preceding pages were printed it has been noticed that the value of the horizontal force at Toronto for the year 1845, assumed by Sir E. Sabine in 1846, and which enters into the factor—

$$\frac{13{\cdot}896}{1{\cdot}836} = 7{\cdot}5686 \qquad \text{I.}$$

employed for converting Relative Force into Absolute Force (*ante,* p. 57), was subsequently corrected by re-estimation of some of the constants. (*See* Toronto, Vol. III. p. cvi, 1857.)

	Horizontal force	Total force.
As published 1846	3·5380	13·904
As corrected 1857	3·5476	13·942

The effect is to alter the above ratio to—

$$\frac{13{\cdot}9086}{1{\cdot}8365} = 7{\cdot}5734 \qquad \text{II.}$$

which slightly augments the values of ϕ. The correction in those cases in which the value in the text is solely deduced from observations with Fox's or Lloyd's needle, assuming a medium force of 14·00, is + 0·0058. Where, however, the value of ϕ is partly deduced from those observations and partly from absolute determinations or vibrations, which are not affected, it is less in proportion to their relative weight. If the weights are equal, it is +·0029, generally from +·002 to +·004. Such a correction in the third decimal may be safely disregarded in a general comparison, but may require notice when data exist for determining the rate of secular change of force which has taken place since 1844.

The above ratio is obtained as follows:—

Total Force at Toronto		ϕ	Phil. Trans. 1846.	
By the Observatory series of X, 1845 .		13·942	p. 244 corrected.	
By the survey magnets . .	1845 .	13·897	Tab. I.	
" " . . .	1846 .	13·887	Tab. II. III.	
Mean by absolute determinations . .		13·9081	—	III.
By Fox needles	1842 .	1·838	Tab. XII.	
" "	1846 .	1·835	Tab. V.	
Mean relative force		1·8365	—	IV.

$$\text{Then } \frac{13{\cdot}9081}{1{\cdot}8365} = 7{\cdot}5734 \text{ as above.}$$

TABLE XIX.

Recapitulation of Magnetical Stations in Geographical Order.

(The figures in the column *W.* signify the relative value of the determination of Force in the preceding column, by the scale explained at p. 41.)

Station number	Station	Lat.	Long.	Var.	Dip	Force, British Units	W.	Force, German Units
14	Washington, U.S. .	° ′ 38 53	° ′ 77 1·0	—	° ′ 71 13·8	13·414	0·6	6·185
13	Baltimore, My. .	39 17	76 37·5	—	71 43·3	13·499	0·6	6·224
12	Philadelphia, Pen. .	39 58	75 10·0	—	71 59·0	13·577	0·6	6·260
42	Mammoth Cave, Ky.	37 10	86 11·0	—	69 18·5	13·415	0·5	6·185
43	Louisville, Ky. .	38 3	85 30·0	—	69 55·5	13·574	0·5	6·259
41	CINCINNATI, Ohio .	39 6	84 27	—	70 28·8	13·548	1·0	6·247
15	Princeton, N.J. .	40 22	74 40	—	72 43·5	13·504	0·6	6·226
8	Manhattanville, N.Y.	40 49	74 3	—	72 35·6	13·426	1·2	6·190
9	Providence, R.I. .	41 50	71 25	—	74 0 0	13·477	0·6	6·214
16	Newhaven, Conn. .	41 18	72 58·0	—	73 27·4	13·453	0·6	6·203
17	West Point, N.Y. .	41 24	74 1·0	—	73 31·5	13·702	0·6	6·318
19	Cleveland, Ohio .	41 30	81 42	—	73 3·8	13·666	0·6	6·301
23	Chicago, Ill. . .	41 53	87 44	—	72 39·3	13·778	0·6	6·353
10	Dorchester, Mass. .	42 19	71 5	—	74 12·8	13·327	0·6	6·145
11	Cambridge, Mass. .	42 22	71 8	—	74 19·5	13·458	0·6	6·205
29	Springfield, Mass. .	42 1·0	72 36	—	73 39·7	13·379	0·6	6·169
18	Albany, N.Y. . .	42 39	73 45	—	74 44·6	13·610	0 6	6·275
37	Buffalo, N.Y. . .	42 55	78 54	—	74 37·8	13·694	0·5	6·314
39	Sarnia, C.W. . .	42 58	82 22	—	74 15 7	13·812	1·0	6·368
20	Detroit, Mich. . .	42 25	83 0	—	73 28·7	13·820	1·1	6·372
38	Amherstburg, C.W. .	42 6	83 3	—	73 30·0	13·760	0·5	6·305
30	Coburg, C.W. . .	43 56	78 10	—	75 27 2	—	—	—
A	TORONTO, C.W. .	43 39	79 21	—	75 14·7	13·896	10·0	6·407
24	Hamilton, C.W. .	43 16	79 50	—	74 55·4	13·824	0·25	6·374
28	Rochester, N.Y. .	43 10	77 46·0	—	74 41	13·670	0·6	6·303
27	Niagara Village .	43 15	79 8·0	—	74 45·6	13·852	0·6	6·387
36	Niagara Falls . .	43 4	79 9	—	74 46·8	13·757	0·5	6·345
40	Goderich, C.W. .	43 45	81 41	—	75 4·8	13 833	1·0	6·378
34	Williamsburg . .	44 55	75 7	—	76 30·8	13·964	0·5	6·438
33	Prescott . . .	44 35	75 30	—	78 42·5	—	—	—
32	Brookville, C.W. .	44 32	75 41	—	76 18·9	13·711	0·5	6·322
22	Kingston, C.W. *a* .	44 13	76 28·6	—	77 15·0	15·047	1·5	6·938
”	” *b* .	44 12	76 29·0	—	?	14·449	0·5	6·662
”	” *c* .	44 13	76 30·0	—	?	15·465	0·5	6·714
31	Belleville, C.W. .	44 9	77 25	—	77 1·0	—	—	—
25	Barrie, C.W. . .	44 21	79 41	—	75 49·9	—	—	—
26	Penetanguishene, C.W. . . .	44 47	79 58	—	76 14·6	14·077	0·45	6·491
4	Kingsey, Q. . .	45 46	72 12	—	77 40	13·687	0·6	6·762
5	Stanstead, Q. . .	45 2	72 7	—	77 19·2	13·642	0·6	6·290
6	St. John's, Q. .	45 17	73 15	—	77 0·1	—	—	—
7	Montreal . . .	45 31	73 33·3	—	77 8·5	13·536	0·5	6·241
35	Cornwall . . .	45 2	74 50	—	76 16·4	13·789	0·5	6·358
1	Quebec . . .	46 49·5	71 14·2	—	77 12·0	13·702	1·1	6·318
2	Three Rivers . .	46 21	72 32	—	77 10·7	13·843	0·6	6·382
3	Sorel	46 2·0	73 3	—	77 16·4	13·751	0·6	6·339
I	St. Helen's. . .	45 31·1	73 31·7	° ′ 8 57·6 W.	77 5·3	13·755	1·7	6·344
II	Isle d'Urval . .	45 25·0	73 44	—	77 3·1	13·645	1·1	6·291
III	La Combe's . .	45 33	74 9	8 26 W.	76 50·6	13·855	0·85	6·388
V	Carillon . . .	45 36	74 30	8 41 W.	—	—	—	—
VII	Pte. du Chene . .	45 37	74 50	7 28 W.	76 55·4	13·622	0·85	6·281
VIII	Alfred Township .	45 37	75 0	6 58 W.	—	—	—	—
IX	Fox's Point . .	45 32	75 22	—	76 35·3	13·877	0·85	6·384
X	Templeton . .	45 29	75 36	8 28 W.	—	—	—	—

TABLE XIX.—*continued.*

Station number	Station	Lat.	Long.	Var.	Dip	Force, British Units	H′.	Force, German Units
		° ′	° ′	° ′	° ′			
XI	Aylmer . . .	45 15	75 58	—	76 41	13·836	0·25	6·384
XII	Chat Falls . .	45 26	76 32	—	75 7	13·916	0·85	6·413
XIII	Port du Fort . .	45 36	76 53	10 11 W.	—	—	—	—
XV	Gr. Calumet . .	45 45	76 40	—	76 44·4	13·832	0·6	6·378
XVI	Fort Coulonge . .	45 51·9	76 45	—	77 29·7	13·911	1·25	6·414
XVII	Pte. Baptême . .	46 5	77 26	—	77 19·1	13·775	0·6	6·351
XVIII	Ptge. 2—Juachims .	46 12	77 40	—	77 3·8	13·830	0·85	6·377
XIX	Roche Capitaine .	46 15	77 45	5 8·8 W.	—	—	—	—
XX	Aberdeen . . .	46 14	77 50	5 33 W.	—	—	—	—
XXII	Trou Portage . .	46 15	78 16	—	77 24·4	13·914	0·85	6·415
XXIII	Mattawa . . .	46 18	78 42·5	3 36·2 W.	—	—	—	—
XXIV	Little River . .	46 15·4	78 44	—	77 28·5	13·956	0·85	6·435
XXVI	Tront Lake . .	46 18·5	79 13	—	77 21·7	13·949	0·85	6·431
XXVII	P. Grande Vase .	46 19·5	79 20	3 15 W.	—	—	—	—
XXVIII	" " W. .	46 18	79 22	4 53·4 W.	—	—	—	—
XXX	L. Nipessing . .	46 11	79 48	—	77 9·5	13·861	0·25	6·391
XXXI	French River . .	46 5	80 20	5 32·1 W.	—	—	—	—
XXXIII	Ricollet's Fall . .	45 57	80 30	—	76 45·4	14·130	0·85	6·515
XXXIV	Penetangnishene .	44 49	80 1	—	76 20·1	14·077	0·3	6·491
A	Toronto . . .	43 39·4	79 21	—	75 14·7	13·896	—	6·407
	Lake Huron							
XXXV	Pte. au Croix . .	45 55·5	81 2	—	76 31·3	13·903	1·15	6·410
XXXVI	George's Island .	45 57	81 32	1 25·6 W.	—	—	—	—
XXXVIII	Frazer Bay . .	46 0	81 40	—	77 5·6	13·906	0·85	6·412
XL	Fort La Cloche .	46 7	82 3	2 10 W.	76 50·2	—	—	—
XLII	Snake Island . .	46 10	82 40	—	77 5·5	13·850	0·85	6·386
XLIII	R. Mississaqui . .	46 10	83 2	2 12·7 E.	—	—	—	—
XLIV	Cranberry Bay .	46 10·7	82 53	0 25·4 W.	—	—	—	—
XLVI	Tessalon Pt. . .	46 17	83 33	0 11·4 W.	76 59·3	14·020	0·85	6·464
XLVII	Bear Camp . .	46 20·2	83 50	0 2·5 E.	—	—	—	—
XLVIII	Sugar Island . .	46 29·7	84 17	1 3·6 E.	—	—	—	—
XLIX	Sault St. Marie .	46 30·9	84 21·5	1 1·1 E.	77 19·5	13·824	0·38	6·374
	Lake Superior.							
L	Pte. aux Pins . .	46 29·9	84 29	—	77 13·4	14·080	1·1	6·492
LI	Pte. au Crêpe . .	46 58·0	84 44	3 2·8 E.	77 11·5	13·959	0·25	6·436
LII	C. Gargantua . .	47 36·9	85 5	0 38·0 E.	77 56·1	15·265	0·3	7·038
LIII	Michipicoton . .	47 56·0	84 54	0 20·3 E.	78 7·2	14·015	1·15	6·315
LV	Chienne R. . .	47 58	85 16	2 21 E.	—	—	—	—
LVI	Le Petit Mort . .	47 56	85 40	3 59·7 E.	—	—	—	—
LVIII	Otter Island . .	48 7	86 7	—	79 43·6	13·568	0·85	6·256
LX	R. Blanche . .	48 31·6	86 14	2 15·2 E.	78 33·1	14·117	0·3	6·509
LXI	The Pic . . .	48 35·3	86 15	5 32·9 E.	78 36·6	13·901	1·15	6·409
LXIII	Battle Island . .	48 45	87 33	—	76 24	13·659	0·3	6·298
LXIV	Simpson's Island .	48 49	87 45	5 44·8 E.	78 53·6	14·020	0·85	6·464
LXVI	Roche du Bout .	48 34	88 14	1 26·7 E.	—	—	—	—
LXVIII	Thunder Cape . .	48 20	88 52	—	78 23·2	14·218	0·85	6·556
LXIX	FORT WILLIAM .	48 23·5	89 13·5	5 47·8 E.	78 4·7	14·078	2·15	6·491
	Canoe Route.							
LXX	Ptge. Ecarté . .	48 25	89 44	—	77 13·5	14·013	0·85	6·461
LXXI	Ptge. de Lisle . .	48 26	89 42	39 18·0 E.	—	—	—	—
LXXII	Mauvais Portage .	48 29	89 44	5 40·8 E.	—	—	—	—
LXXIII	Dog Portage . .	48 39	89 30	—	78 26·8	14·121	1·15	6·512
LXXIV	Dog Lake . .	48 44	89 40	6 51·1 E.	—	—	—	—
LXXVI	Prairie Portage .	48 57·5	90 1·5	—	78 26·1	14·086	1·15	6·495
LXXVIII	Savannah Portage .	48 53	90 3·2	7 38·3 E.	78 21·8	14·107	0·85	6·504

TABLE XIX.—*continued.*

Station number	Station	Lat.	Long.	Var.	Dip	Force, British Units	W.	Force, German Units
		° ′	° ′	° ′	° ′			
LXXX	French Portage .	48 35	91 8·4	—	78 20·4	14·069	0·85	6·487
LXXXI	Ptge. des Morts .	48 36	91 25	10 39·5 E.	—	—	—	—
LXXXII	Ptge. Two Rivers .	48 35	91 23	10 57·6 E.	77 49·4	14·031	1·15	6·469
LXXXIII	L. à la Crosse . .	48 24	92 4	7 52·5 E.	77 51·0	14·063	0·85	6·484
LXXXV	2nd Portage . .	48 14·2	92 25	10 20·5 E.	77 40·1	14·026	0·85	6·467
LXXXVII	Sturgeon Lake .	48 27·5	92 38	—	77 44·8	14·077	0·85	6·491
LXXXVIII	1st Portage . .	48 28	92 41	10 25·2 E.	—	—	—	—
LXXXIX	Rainy Lake . .	48 33·4	92 50	10 53·6 E.	77 47·9	14·095	0·85	6·499
XC	FORT FRANCES .	48 36·6	93 26·7	9 35·0 E.	77 30	14·023	1·80	6·466
XCI	Rainy River . .	48 41	94 31	13 4·5 E.	77 57·4	14·309	1·1	6·597
XCIV	L. of the Woods .	49 19	94 40	13 42·6 E.	78 3·7	14·110	0·85	6·489
XCVII	,, ,, .	49 25	94 37	12 26 E.	78 16·7	14·044	0·85	6·475
C	Rat Portage . .	49 45·9	94 33·3	9 38 E.	78 7·5	14·023	1·3	6·466
CII	In Winnipeg River .	50 10·2	95 12	12 28·7 E.	79 10·6	14·204	0·6	6·549
CIV	Slave Falls . .	50 14·7	95 40	—	78 57·1	14·094	0·6	6·498
CVI	Pinnawa River .	50 16	96 3	12 48·6	—	—	—	—
CVIII	FORT ALEXANDER .	50 36·9	96 22	13 55·5 E.	78 58·4	14·098	0 9	6·500
CX	Lake Winnipeg .	50 35	96 35·6	13 41 E.	78 34 4	14·128	0·6	6·514
CXI	,, .	50 33·4	96 36	—	79 5·1	—	—	—
CXIII	FORT GARRY . .	49 53 2	97 15·6	16 4·8 E.	78 18·8	14·050	2·8	6·478
CXIV	Red River . .	50 18·2	96 52	—	78 34	14·094	0·85	6·498
CXVII	Lake Winnipeg .	51 4	96 26	—	79 31·5	14·516	0·30	6·693
CXVIII	,, .	51 34	96 43	15 6·7 E.	79 6·1	14·393	0·30	6·636
CXVI	,, .	51 3·6	96 56	13 45·5 E.	79 11·8	14·090	0·85	6·497
CXIX	,, .	51 36·7	96 53	16 25·1 E.	79 38·0	14·462	0·85	6·668
CXXII	,, .	51 40	96 56	21 38·3 E.	—	—	—	—
CXXI	,, .	51 44 5	97 2	15 24·2 E.	79 39 0	15·382	0·3	7·092
CXXIV	,, .	51 46	97 0	—	79 28·3	14·414	1·25	6·646
CXXVI	,, .	52 6·5	97 8	15 38·6 E.	—	—	—	—
CXXVIII	,, .	52 20·9	97 10	16 54·6 E.	80 24·4	14·396	0·3	6·638
CXXIX	,, .	52 22·6	97 12	14 19·8 E.	80 39·2	14·150	0·6	6·524
CXXX	,, .	52 25	97 18	19 22·7 E.	—	—	—	—
CXXXI	,, .	52 31·6	97 18	19 12·2 E.	80 5·5	14·113	2·1	6·492
CXXXIV	Old Norway House .	53 41·6	98 1·4	—	80 45·4	14·162	0·9	6·530
CXXXVI	NORWAY HOUSE .	53 59·6	98 3·9	15 35 0 E.	81 10·0	14·098	8·15	6·500
	Canoe Route.							
CXXXVIII	Carpenter's Lake .	54 14	97 40	21 26·0 E.	—	—	—	—
CXL	Hairy Lake . .	54 20	97 28	18 43·7 E.	81 20·9	14·067	0·8	6·486
CXLI	Lakelet . . .	54 23	97 4	35 11·2 E.	—	—	—	—
CXLII	Echiamamis . .	54 21	97 2	19 5·3 E.	—	—	—	—
CXLIV	White Fall Portage .	54 23·3	96 31	17 32 E.	81 47·9	14·203	0·8	6·549
CXLV	Hills Gates . .	54 42	96 10	—	81 57·0	14·194	1·2	6·543
CXLVIII	Oxford Lake . .	54 46·8	96 9	12 53·6 E.	—	—	—	—
CL	,, House . .	54 56	95 30	10 31·5 E.	82 38·8	14·192	1·0	6·544
CLIII	Knee Lake . .	54 51	95 11	14 16·2 E.	—	—	—	—
CLV	Long Portage . .	55 14·1	94 22	12 36·4 E.	82 13·9	14·210	1·85	6·552
CLVII	Devil's Handing Pl.	55 24	94 0	11 49·4 E.	82 55	14·227	0·8	6·560
CLVIII	Morgan's Rocks .	55 29	93 53	11 11·0 E.	—	—	—	—
CLIX	White Mud Portage.	55 33	93 44·6	10 51 E.	83 2·9	14·134	1·6	6·517
CLXI	Shawatawa . .	56 21	93 0	11 10 E.	83 36·2	14·130	1·65	6·515
CLXII	YORK FACTORY[1] .	56 59·9	92 26	9 0·6 E.	83 47·2	14·051	2·50	6·480
CLXIII	Lake Winnipeg .	53 53	98 39	17 24·2 E.	—	—	—	—
CLXV	Macintosh Island .	53 40	99 5	21 39·4 E.	—	—	—	—
CLXVI	Lake Winnipeg .	53 31·9	99 12	17 7·3 E.	80 22·2	14·098	1·5	6·500
CLXVII	Saskatchewan . .	53 17	99 25	16 39·2 E.	—	—	—	—
CLXIX	Grand Rapid . .	53 8·4	99 27	18 19·0 E.	80 26·5	14·141	1·55	6·524
CLXX	Cross Lake . .	53 10·7	99 34	18 3·7 E.	80 28·2	14·165	1·85	6·531
CLXXI	Hare Island . .	53 12·9	100 0	—	80 7·1	14·063	0·6	6·484
CLXXIII	Muddy Lake . .	53 19·3	100 35	18 32·9 E.	—	—	—	—

[1] For Dr. J. Rae's observations, *see* Table XVI. p. 116.

TABLE XIX.—*continued.*

Station number	Station	Lat.	Long.	Var.	Dip	Force, British Units	W.	Force, German Units
CLXXIV	Devil's Drum Island.	53° 19′5	100° 36′	17° 32′·2 E.	80° 0′·0	13·814	0·3	6·370
CLXXVIII	Round Turn . .	53 48·8	101 23	19 56·8 E.	80 24·4	14·318	0·3	6·755
CLXXIX	Big Bend . . .	53 52·0	101 28	20 45·4 E.	—	—	—	—
CLXXXI	Little River . .	53 51	101 50	17 45·2 E.	—	—	—	—
CLXXXIII	CUMBERLAND Ho. .	53 56·7	102 19·2	19 32·5 E.	80 25·0	14·143	4·2	6·521
CLXXXIV	Pine Island Lake .	53 58	102 17	17 59·7 E.	—	—	—	—
CLXXXVI	River Malign . .	54 21·4	102 10	21 23·0 E.	—	—	—	—
CLXXXVIII	Limestone Point .	54 26	102 10	—	80 34·2	14·032	1·3	6·470
CXC	Carp Portage . .	54 47·2	102 39·5	24 8·6 E.	80 39·6	—	—	—
CXCI	Pine Portage . .	55 4	102 42	—	80 52·7	14·109	1·3	6·505
CXCII	Frog Portage . .	55 27	103 19·5	—	80 59·3	14·017	1·3	6·463
CXCV	Little Rock Portage.	55 30	104 34	16 27·3 E.	80 16·4	15·071	1·1	6·949
CXCVII	Great Devil's Ptge. .	55 40	104 47·7	24 48·5 E.	80 30·9	14·118	1·2	6·509
CC	Trout Portage .	55 42·5	105 29	21 28·0 E.	—	—	—	—
CCIII	Rapide qui parle .	55 43·5	105 50	21 15·9 E.	—	—	—	—
CCV	Pine Portage . .	55 43	106 0	—	80 40·3	14·023	1·1	6·466
CCVI	Snake Point . .	55 51	106 38	26 17·8 E.	—	—	—	—
CCVII	„ Rapid . .	55 44·1	106 35·2	—	80 38·8	14·150	1·0	6·686
CCIX	Primean Lake . .	55 57	107 10	23 15·9 E.	—	—	—	—
CCX	Ptge. Sonnante .	55 54	107 36	26 43·4 E.	80 11·2	14·050	0·9	6·478
CCXI	Fort à la Crosse .	55 26·8	107 54	24 54·7 E.	80 9·8	14·012	3·8	6·512
CCXII	Buffalo . . .	56 4	108 40	—	80 37	14·022	0·63	6·465
CCXV	Long Portage . .	56 14·7	109 18	28 36·5 E.	80 19·7	13·865	0·63	6·393
CCXVI	Pine Portage . .	56 20	109 14	25 29·5 E.	—	—	—	—
CCXVII	Methy Portage .	56 35	109 37	26 51·4 E.	80 36·4	13·980	0·63	6·446
CCXVIII	„ N. end . .	56 43·7	109 52·2	28 28·6 E.	80 38·3	—	—	—
CCXX	Big Rock Portage .	56 43·5	110 4	27 48·8 E.	—	—	—	—
CCXXI	Cascade Portage .	56 42·5	110 15	26 49·6 E.	—	—	—	—
CCXXIII	Pembina River .	56 39	110 55	—	80 36·2	13·959	0·63	6·421
CCXXVI	Pierre au Calumet .	57 24	111 35	25 43·6 E.	81 16·8	14·559	0·63	6·712
CCXXVII	Pt. Brulé . .	58 7	111 25	—	81 30·6	13·933	0·63	6·424
CCXXIX	FORT CHIPEWYAN .	58 43	111 18·7	28 45·8 E.	81 36·8	13·885	3·95	6·402
	Peace River.							
CCXXXI	Pt. Providence .	58 58	112 10	30 35 E.	81 46·1	—	—	—
CCXXXIV	On Peace River .	58 58	112 56·1	32 24 E.	81 36·9	—	—	—
CCXXXVII	Poplar Island . .	58 39	114 10·7	26 29·8 E.	81 4·8	—	—	—
CCXXXIX	The Falls . . .	58 24·3	114 51·1	30 22 E.	80 50·8	—	—	—
CCXLII	FORT VERMILION .	58 24·5	115 58·6	32 40 E.	80 48·0	14·022	1·55	6·465
CCXLVI	Baril River . .	57 57	117 4·7	29 56 E.	80 0·7	—	—	—
CCL	On Peace River .	57 19	117 1·7	28 53 E.	79 27·0	—	—	—
CCLIV	Near R. Cadotte .	56 47	117 2	27 3 E.	79 26·7	—	—	—
CCLX	FORT DUNVEGAN .	55 55·6	118 28·5	27 16·5 E.	78 46·2	14·000	1·45	6·455
CCLXIV	FT. LESSER SLAVE L.	55 32·6	116 0	26 52·5 E.	78 39·0	13·872	0·3	6·108
CCLXVI	Swan Point . .	55 26	115 3·1	26 19·0 E.	78 29·9	—	—	—
CCLXIX	Forks of the Athabasca . . .	55 13	113 53·2	26 28·0 E.	78 55·2	—	—	—
		—	—	—	78 34·1	—	—	—
CCLXXIII	On Athabasca River.	54 43	114 2	26 29·1 E.	—	—	—	—
CCLXXVII	FORT ASSINIBOINE .	54 21·7	114 28·6	24 39 E.	78 15·2	—	—	—
CCLXXIX	Pembina River .	54 3·2	114 0·2	22 23 E.	77 54	—	—	—
	R. Saskatchewan.							
CCLXXX	FORT EDMONTON .	53 31·9	113 30·3	23 47 E.	77 54·2	14·000	1·45	6·155
CCLXXXI	On Saskatchewan .	54 4·5	112 19·5	24 25 E.	78 5·2	13·705	0·3	6·319
CCLXXXIII	Moose Hill . .	53 50	110 59	21 26·6 E.	78 33·5	13·812	0·3	6·368
CCLXXXIV	FORT PITT . .	53 34·1	109 47·2	23 9·2 E.	78 41·0	14·154	0·3	6·526
CCLXXXV	Willow Hills . .	53 0·1	108 30.	28 21·1 E.	78 28·1	14·243	0·3	6·567
CCLXXXVII	Elbow . . .	52 21·4	107 23	25 21·4 E.	78 16·6	14·088	0·3	6·496
CCLXXXIX	CARLTON . . .	52 50·8	106 32	22 55 E.	78 30·7	13·782	0·37	6·355
CCXC	Near Fort à la Corne.	53 13	101 51·6	24 45 E.	79 11·2	13·924	0·3	6·120

TABLE XIX.—*continued.*

Station number	Station	Lat.	Long.	Var.	Dip	Force, British Units	W.	Force, German Units
	Northern Section.							
		° ′	° ′	° ′	° ′			
CCXCII	FORT GOOD HOPE .	66 16	128 31	—	82 55·9	13·681	0·6	6·309
CCXCIV	FORT NORMAN . .	64 40·6	124 44·8	—	82 34·3	13·653	0·57	6·295
CCXCV	FORT SIMPSON . .	61 51·7	121 25·3	38 0·4 E.	81 52·2	13·808	1·5	6·367
CCXCVII	Burnt Point . .	61 10	119 9	36 4·0 E.	—	—	—	—
CCXCIX	Sandy Point . .	61 20	118 0	38 5 E.	—	—	—	—
CCCI	River . . .	61 25	117 31	36 7 E.	—	—	—	—
CCCIII	Fishing Station .	61 11·7	116 38	35 28 E.	82 8·7	13·836	0·2	6·379
CCCV	Hay River . .	60 48	115 18	35 56·0 E.	—	—	—	—
CCCVII	FORT RESOLUTION .	61 10·7	113 46	37 12·5 E.	82 44·4	13·956	0·45	6·435
CCCX	Ptge. de Gr. Détour .	60 22	113 0	35 15·0 E.	82 33·6	—	—	—
CCCXIV	Pelican Portage .	59 58	111 51	36 15 E.	82 26·8	—	—	—

APPENDIX I.

INDUCTION MAGNETOMETER.

For the convenience of any reader who may not have access to the writings of the late Provost Humphrey Lloyd, D.D., referred to at pp. 42 and 45 (note), I subjoin his exposition of the theoretical principles upon which the beautiful instrument above-named was devised, extracted from the 'Proceedings of the Royal Irish Academy, 1842,' and the 'Dublin Magnetical and Meteorological Observations,' vol. i., 1865.

'When a bar of soft iron is held in any direction not perpendicular to that of the earth's magnetic force, it becomes a temporary magnet by the inducing action of that part of the force which acts in its direction. The changes in the induced magnetism may be assumed to be proportioned to those of the inducing force; and as the former may be measured by their effects, the latter become known' (1865.)

Let X and Y denote the horizontal and vertical components of the earth's magnetic force, M the intensity of the permanent magnetism in the acting pole of the iron bar, and m the magnetic moment of the suspended magnet. The intensity of the induced magnetism is by the hypothesis equal to

$$K\ Y,$$

K being an unknown constant; and when this is of the same name as the permanent magnetism, the intensity of the acting force at the unit of distance is

$$K\ Y + M.$$

Accordingly, the moment of this force to turn the suspended magnet is $(K\ Y + M)\ m\ r \cos u$, u being the angle of deflection, and r a constant depending on the distance; or making for abridgment $k\ r = p$, $M\ r = q$.

$$(p\ Y + q)\ m \cos u.$$

But this deflecting force is resisted by the earth's horizontal force, the moment of which to turn the magnet is

$$X\ m \sin u,$$

and the magnet will rest when these moments are equal. Hence the equation of equilibrium is

$$p\,Y + q = X \tan u. \qquad (1)$$

By the same reasoning it will appear, that when the induced and permanent magnetisms are of contrary names, there is

$$p\,Y - q = X \tan u' \qquad (2)$$

in which u' is the new angle of deflection when the bar is inverted. Adding these equations together, and remembering that $Y = X \tan \theta$, θ being the inclination, we have

$$2\,p \tan \theta = \tan u + \tan u' \qquad (3)$$

This equation would furnish at once the inclination sought, provided we knew the value of the constant K. In order to determine it, we have only to place the iron bar *horizontally* in the magnetic meridian, its acting pole remaining in the same place as before, but pointing alternately to the north and to the south. The inducing force is in this case the *horizontal component* of the earth's magnetic force; and it will be readily seen that the equations of equilibrium are similar to (1) and (2), substituting X for Y. If, therefore, v and v' denote the angles of deflection in these positions, we have

$$2\,p = \tan v + \tan v' \qquad (4)$$

and dividing (3) by this,

$$\tan \theta = \frac{\tan u + \tan u'}{\tan v + \tan v'} \qquad (5)$$

Thus, from the deflections thus produced in these four positions of the bar, we obtain the inclination" (1842.)

The author proceeds to show how changes of inclination are to be inferred from changes in the scale reading of the instrument, by the formula

$$\triangle\,\theta = \frac{\sin 2\,\theta}{\sin 2\,u} \triangle\,u,$$

With these, however, we are not at present concerned.

The Induction Magnetometer had reached this stage of its development, when furnished to the writer for employment in high Northern latitudes subsequently it received many improvements at the hands of its inventor and of Dr. Lamont, of Munich, the chief of which was the addition of a second soft-iron bar; and on more full investigation Dr. Lloyd found it necessary to introduce a second unknown co-efficient q to be determined experimentally. This was never done for the American instrument, which was shortly afterwards sent to India. The observations recorded in the text are given chiefly as interesting to show the great range of the angles u and u' in high magnetic latitudes, and for any use they may be to future travellers meditating its employment.

APPENDIX II.

IDENTIFICATION OF THE STATIONS INCLUDED IN TABLE XIV. pp. 52–54.

1. Quebec, *a*, within the ramparts, on a grass plot in front of the then Artillery Barracks.
   ,, *b*, near Wolfe and Montcalm's monument.
2. Three Rivers, in the garden of the late Mr. Bell.
3. Sorel, on the bank of the river, a little east of the Roman Catholic Church.
4. Kingsey, Drummond Co. L.C., in the garden of Captain Cox.
5. Stanstead, in the garden of the hotel near the Anglican Church.
6. St. John's, or Dorchester, behind the hotel about a quarter of a mile above the bridge.
7. St. Helen's Island, Montreal, about 100 yards S.S.W. of the barracks.

7*a*. Montreal, at the foot of the mountain in the garden of the house then rented as the quarter of the commanding Royal Engineer.

8. Manhattanville, N.Y., in a grove behind the Bloomingdale Lunatic Asylum, formation, mica slate.
9. Providence Rhode Island, at the steamboat landing.
10. Dorchester, Mass., near Grove Hall.
11. Cambridge, Mass., in the garden of the Observatory, not less than 30 feet from the magnetical instruments.
12. Philadelphia, at Girard's College.
13. Baltimore, *a*, at Dr. Bache's station in Howard's Wood, between Calvert and Washington Streets, about 400 yards N. 42° E. from the Washington monument.
    ,, *b*, about 600 yards N. of the same monument.
    ,, *c*, in the Botanical Garden, St. Mary's College, at Dr. Nicolet's station.
14. Washington, D.C., in the grounds of the Capitol, west side of the lowest terrace between the centre and south alleys.
15. Princeton, N.J., in a field 200 yards behind the college, and to the right of it.
16. Newhaven, Conn., on a void space in Grove Street, about 50 yards S. of the entrance to the Cemetery, and 36 yards from the iron fencing.

17. West Point, N.Y., in Professor Bartlett's garden.
18. Albany, N.Y., Professor J. Henry's station, on the side of the hill between Orange and Patroon Streets, and E. of Hawk Street, N. 13° E. from the Boys' Academy, N. 40° W. from the Dutch Church.
A. TORONTO, at the Observatory.
19. Cleveland, Ohio, at the foot of a hill about 20 yards from the landing.
20. Detroit, Mich., in a lane leading from the wharf to Jefferson Avenue, about 40 yards down.
21. South Manitou Island, Lake Michigan, about 40 yards from the wharf directly inland, under shelter of a hut.
22. Kingston, Canada, *a*, in the Artillery Square, near the flagstaff.
,, ,, *b*, at Stewart's Point.
,, ,, *c*, on Kingston Common, near the Penitentiary.
23. Chicago, Ill. (not specified).
24. Hamilton, Lake Ontario, in the courtyard of the Farmer's Inn, 300 yards E. of the market-place, and about a mile W. of the landing.
25. Barrie, Lake Simcoe, about 60 yards from the lake in the garden of the hotel (then Bingham's Hotel).
26. Penetanguishene, Lake Huron, *a*, near Mrs. Wallace's Inn, about a quarter of a mile from the Barracks. *b*, in front of the Freemasons' Arms Inn.
27. Niagara Village, Lake Ontario, outside the fort in the garden of the Royal Engineers' quarter.
28. Rochester, N.Y., at the corner of Mill Street, in a garden behind the Mansion House Hotel (Whitbeck's).
29. Springfield, Mass., in a yard W. of the American Hotel, about 60 yards from the railroad.
30. Coburg, Ontario, in a yard adjoining Mr. Parry's House, nearly opposite a church.
31. Belleville, Bay of Quinté, in Dr. Reilly's garden.
32. Brockville Garden, Rockford's Hotel.
33. Prescott, in a field about 500 yards back from the river, and 150 yards from the fort, opposite Ogdensburg.
34. Williamsburg, Garden of Broueffle's Inn.
35. Cornwall, in the orchard behind Chesley's Inn.
36. Niagara Falls, near the Clifton Hotel.
37. Buffalo, behind the High School at the corner of Fourth and Delaware Streets.
38. Amherstburg, in Mr. J. Gordon's garden.
39. Sarnia, in a garden near the Ferry.
40. Goderich, in a garden at the foot of the hill.
41. Cincinnati, in Mr. Longworth's garden, between Pike, Butler, and Symms Streets.

42. Mammoth Cave, Kentucky, taken at the mouth of the cave, which is situated a little to the S.W. of a line joining Glasgow and Litchfield, Ky., at about one-third of the distance measured from the former. The spot was 40 feet S.E. from the House.

43. Louisville, Ky., about a quarter of a mile S.S.W. of the Hospital, and half a mile from the river, in Jacob's Wood.

APPENDIX III.[1]

Comparison of the mean Irregular Fluctuations of the magnetical elements at stations of observation in North America, reprinted from the 'Proceedings of the American Association for the Advancement of Science, 1851.'

These results were arrived at by taking the difference between the observed scale reading at each hour of Göttingen mean time and the arithmetical mean for the same hour for the month. The *square root of the mean of the squares* of these differences is the quantity entered as the mean disturbance for the hour. It should be borne in mind that the years of observation 1843–4 coincided with a minimum of sun-spots.

Table XX.

Mean disturbance of the declination, October–February.

Local mean time	Toronto	Sitka	Lake Athabasca	Local mean time	Toronto	Sitka	Lake Athabasca
Midnight	1′,72	4′,36	8′,5	Noon	1′,61	2′,67	4′,6
13	1 ,33	4 ,18	9 ,9	1	1 ,54	2 ,55	4 ,3
14	1 ,60	3 ,62	8 ,6	2	1 ,34	2 ,20	4 ,7
15	1 ,59	2 ,97	7 ,4	3	1 ,71	2 ,14	4 ,7
16	1 ,52	2 ,92	11 ,0	4	1 ,81	1 ,95	4 ,4
17	1 ,67	2 ,84	15 ,2 [2]	5	1 ,86	1 ,81	3 ,7
18	1 ,75	2 ,75	10 ,6	6	1 ,02	1 ,90	4 ,3
19	1 ,29	2 ,82	8 ,5	7	0 ,84	3 ,09	3 ,8
20	1 ,82	2 ,88	5 ,5	8	1 ,53	2 ,47	4 ,6
21	1 ,89	2 ,80	4 ,6	9	2 ,16	2 ,51	6 ,3
22	1 ,52	3 ,10	5 ,1	10	2 ,72	3 ,43	10 ,2
23	1 ,68	2 ,79	7 ,0 [3]	11	2 ,27	3 ,32	9 ,7

In the next table, the same two stations are compared with Fort Simpson, on M'Kenzie's river, in lat. 61° 52′, long. 8^h 5^m W. The period of observation compared is here the months of April and May 1844; embracing, however, only 46 observation days at the most northern station, but the full number at the others. Sundays are included at Sitka in both cases.

[1] See Note p. 9.

[2] By omitting one observation on January 25^d 1^h Gött., when the extreme point of a great movement happened to coincide with the regular hour of observation, this value is reduced to 10,6′.

[3] By omitting a similar extreme observation on February 2^d 7^h Gött., this value is reduced to 6,7′.

TABLE XXI.

Mean disturbance of declination, April–May 1844.

Local mean time	Toronto	Sitka	Fort Simpson	Local mean time	Toronto	Sitka	Fort Simpson
Midnight	2′,89	5′,18	14′,5	Noon	2′,05	2′,58	8′,0
13	3 ,16	6 ,57	11 ,7	1	1 ,84	2 ,22	4 ,6
14	3 ,83	5 ,42	15 ,8	2	1 ,71	2 ,31	7 ,0
15	4 ,62	8 ,01	22 ,2	3	1 ,56	2 ,81	6 ,3
16	3 ,77	8 ,92	17 ,3	4	1 ,68	2 ,36	6 ,2
17	2 ,42	5 ,08	25 ,6	5	1 ,88	2 ,96	7 ,4
18	2 ,43	3 ,60	22 ,9	6	2 ,04	4 ,03	8 ,1
19	3 ,97	2 ,69	22 ,3	7	2 ,78	4 ,16	8 ,8
20	2 ,91	2 ,49	19 ,7	8	2 ,29	2 ,91	12 ,3
21	2 ,16	2 ,10	12 ,0	9	2 ,94	3 ,51	15 ,4
22	2 ,08	2 ,46	12 ,2	10	4 ,58	3 ,90	13 ,1
23	2 ,24	2 ,57	6 ,2	11	2 ,73	3 ,58	9 ,2

The observations at Toronto were taken $2^m\ 21^s$ after the hours named; those at Sitka, $19^m\ 5^s$ after; those at Lake Athabasca, $5^m\ 1^s$ after; and those at Fort Simpson, $14^m\ 33^s$ before the hours named.

It is not to be expected that the observations of periods so short as five months and two months should exhibit the diurnal law of mean disturbance with much regularity, unless at stations peculiarly liable to that effect. Lake Athabasca and Fort Simpson are such stations, and here the law is strongly marked: the corresponding periods at the other stations are introduced for strict comparison; but we must take a longer period, as in the next table (p. 178), to which I have added Philadelphia,[1] to make their characteristics in this respect fully evident.

The year 1843 was selected by Dr. Lloyd for this investigation, on account of its freedom from great disturbances: 'on the grounds that the number which denotes the frequency of the irregular changes, in consequence, bearing a larger proportion to that which denotes their magnitude, any regular law to which they are subject will be more readily apparent.' The observations of 1843 at Toronto, as compared with those of the following year, show that this absence of disturbance was equally characteristic at that station. The observations at Philadelphia and Sitka belong principally to the year 1844, the period examined being the twelve months commencing October 1843.

It appears by the following table, that at each of the American stations the mean disturbance of the declination has its lowest value in the afternoon, and that this is succeeded by a maximum at 9 or 10 P.M. So far, therefore, the diurnal law at all the stations agrees with that deduced by Dr. Lloyd from his own observations, namely, that 'during the day, *i.e.* from 6 A.M. to 6 P.M., the mean disturbance is nearly constant; at 6 P.M. it begins to increase, and arrives at a maximum a little after 10 P.M.' When, however, Dr. Lloyd proceeds to state, 'it then decreases

[1] *Magnetical and Meteorological Observations at Girard College*, by Dr. A. D. Bache, 1840–45.

with the same regularity, and arrives at its constant day value at about 6 A.M.,' he describes a feature which is evidently *not* characteristic of all the stations, and is more completely wanting as we proceed to the north.

TABLE XXII.

Mean disturbance of the declination for twelve months at Philadelphia and Sitka, and for two years at Toronto; to which are added, for comparison, the corresponding values given by Dr. Lloyd for the year 1843, *from the observations at Dublin.*[1]

Local mean time	Dublin	Philadel.	Toronto		Sitka
			1843	1844	
Midnight	—	2′,22	1′,78	3′,03	4′,57
13	2′,81	2,10	2,06	2,72	4,95
14	—	2,29	1,91	2,62	4,07
15	2,52	2,29	1,92	2,89	4,35
16	---	1,91	1,83	2,85	4,93
17	2,16	2,10	2,17	2,72	3,51
18	—	2,06	2,25	2,53	3,03
19	1,93	2,20	1,82	3,08	2,86
20	—	2,00	1,67	2,28	2,91
21	1,89	2,19	1,98	2,07	2,65
22	—	1,91	1,91	2,08	3,14
23	1,93	1,93	1,85	2,14	2,83
Noon	—	1,81	1,93	1,88	2,60
1	2,17	1,65	1,83	1,80	2,40
2	—	1,76	1,66	1,92	2,22
3	2,11	1,77	1,70	1,83	2,38
4	—	1,74	1,83	1,76	2,45
5	2,12	1,67	1,73	1,96	2,52
6	—	1,62	2,05	1,87	2,71
7	2,44	1,86	1,87	1,95	3,82
8	—	2,52	2,56	3,35	4,50
9	3,47	2,61	2,43	3,56	4,05
10	—	2,59	2,44	3,38	4,42
11	4,07	1,88	2,32	2,88	3,67

The following are the arithmetical means of the values for each quadrant of the twenty-four hours:

TABLE XXIII.

	Midn. to 5 a.m.	6 to 11 a.m.	Noon to 5 p.m.	6 p.m. to midn.
Dublin . .	2′,50	1′,92	2′,14	3′,32
Philadelphia .	2,15	2,05	1,73	2,18
Toronto 1843 .	2,11	1,91	1,78	2,28
Toronto 1844 .	2,80	2,36	1,86	2,83
Sitka . . .	4,40	2,90	2,43	3,86

It will be seen that at Philadelphia and Toronto, the mean value from midnight to 5 A.M. is somewhat less than in the quadrant preceding midnight; but the difference is materially less in proportion than at Dublin: at Sitka, the highest value is after midnight. Arranging in like manner the values for the shorter periods in Tables I. and II., we find the same

[1] *Transactions of the Royal Irish Academy*, vol. xxii., pt. i.

general law, but with a greater excess after midnight at Lake Athabasca than at Sitka, and a yet greater at Fort Simpson than at Lake Athabasca.

TABLE XXIV.

Mean disturbance of declination, October 1843 to February 1844.

	Midn. to 5 a.m.	6 to 11 a.m.	Noon to 5 p.m.	6 p.m. to midn.
Toronto . .	1′,57	1′,66	1′,64	1′,76
Sitka . . .	3 ,48	2 ,86	2 ,22	2 ,79
Lake Athabasca .	9 ,33	6 ,88	4 ,40	6 ,48

TABLE XXV.

Mean disturbance of declination, April and May 1844.

	Midn. to 5 a.m.	6 to 11 a.m.	Noon to 5 p.m.	6 p.m. to midn.
Toronto . .	3′,45	2′,63	1′,79	2′,89
Sitka . . .	6 ,53	2 ,65	2 ,54	3 ,68
Fort Simpson .	17 ,85	15 ,88	5 ,68	11 ,15

The observations of April and May at Sitka include nine days which were not days of observation at Toronto, and fourteen which were not days of observation at Fort Simpson, where there were also a few omissions in the six-hourly period commencing at midnight: this may account for the somewhat lower relative value in that quadrant as compared with the one preceding it, at the latter station, than at Sitka.

The above comparison exhibits a marked difference in the state of disturbance prevailing after midnight at Sitka, Lake Athabasca, and Fort Simpson, as compared with the lower stations. Of the six hours preceding midnight, however, only 9^h, 10^h, and 11^h are distinguished for a high value of this quantity at any of the stations: it will perhaps be better therefore to compare these three hours with 3^h, 4^h, and 5^h A.M. particularly; hours to which no prominent interest was assigned by any of the authorities quoted above. I have here taken, in each instance except Dublin, the value of $\sqrt{\frac{\Sigma(\Delta^2)}{N}}$: it is also necessary to substitute at Dublin some of the values of 1843 for the corresponding months of 1844; but this will not affect the comparison. Taking the same periods at all the stations, we have the following results:

TABLE XXVI.

	FIVE WINTER MONTHS		TWO SPRING MONTHS	
	9–11 p.m.	3–5 a.m.	9–11 p m	3–5 a.m.
Dublin . . .	2′,70	1′,75	5′,27	2 ,71
Philadelphia . .	1 ,85	1 ,47	2 ,17	2 ,46
Toronto . . .	2 ,35	1 ,59	3 ,51	4 ,17
Sitka . . .	3 ,10	2 ,80	3 ,43	7 ,50
Lake Athabasca .	8 ,89	11 ,63	—	—
Fort Simpson .	—	—	12 ,89	21 ,57

Again: for the whole year, we have

TABLE XXVII.

	9–11 p.m.	3–5 a.m.	Ratio
Dublin . . .	3′,77	2′,34	As 1,61 : 1
Philadelphia . .	2 ,38	2 ,11	1,13 : 1
Toronto { 1843 .	2 ,39	1 ,98	1,21 : 1
Toronto { 1844 .	3 ,13	2 ,82	1,11 : 1
Sitka . . .	4 ,19	4 ,28	0,97 : 1

The highest values would be given at Sitka by the hours 12^h, 1^h, 2^h A.M. both in the winter period and on the whole year, and by 2^h, 3^h, 4^h A.M. in the two spring months, which appears to show an earlier epoch for the second reaction than at the other two northern stations; but probably the reduction of another year's observations, at least, will be necessary to determine this point.

It appears then that while at Philadelphia and Toronto, as at Dublin, the mean disturbance of the declination presents but one maximum, which occurs at 9 or 10 P.M., yet there is not, even at these stations, a complete agreement. At Dublin, the value decreases regularly after 11 P.M.; at Philadelphia and Toronto, it decreases to a materially less degree. Proceeding to Sitka, we find a maximum about the same hour, but it is succeeded by another at 1 A.M., and the average value is somewhat greater for the hours succeeding than for those preceding midnight. At Lake Athabasca we have still a maximum about 10 P.M., but it is decidedly inferior to a second maximum at 5 A.M. or thereabouts. Lastly, at Fort Simpson, without losing the first maximum, we find it exceeded in a still higher ratio by the second. Hence we are led to the conclusion that, as regards the declination, there are two classes of irregular influences, or two reactions during the night, succeeding the regular influences which have acted during the day. Of these, the one which produces a maximum value of disturbance at 9 or 10 P.M. appears to be universal, but it is nowhere important enough to modify in any marked degree the character of the mean diurnal curves of this element, which is chiefly impressed, at all save the most northern stations, by the direct or regular action of the day. The other class, or that which produces a second maximum of disturbance after midnight (when the direct action of the sun is on the opposite hemisphere), is not universal, but comes into operation, on the American continent, more and more effectively as we approach the magnetic pole; until at last its energy is such as to mask the effect of the more feeble regular influences, and to determine almost entirely the apparent character of the mean diurnal changes.

I have hitherto referred to the disturbance of the declination alone, that being the element which has been most generally studied, and which alone has given a marked maximum of disturbance at 9^h or 10^h P.M. The horizontal force and the inclination, at Lake Athabasca and Fort Simpson, equally support the conclusion that the causes producing disturbance at these stations come into operation chiefly towards morning, and concur in showing 4^h or 5^h A.M. to be the period of their greatest effect. The result is that the principal inflexion in the mean diurnal curve for each element occurs at that hour also, giving to these curves an apparent character differing most remarkably from those described elsewhere.

It can scarcely be necessary to point out the great comparative amount of the mean disturbance shown at the two most northern stations. The effect of this greater prevalence of disturbance is strikingly shown in the great amount of the mean daily range of the elements. Taking the difference between the highest and lowest scale reading of each day for the daily range, and $\sqrt{\frac{\Sigma(\Delta^2)}{N}}$ for the *mean* daily range, we have the following remarkable series :—

Table XXVIII.

	Five winter months		Two spring months	
	Declination	Horizontal force	Declination	Horizontal force
At Philadelphia .	7′,1	,00132 X	11′,4	,00157 X
Toronto .	8 ,5	,00242 X	14 ,0	,00357 X
Sitka . .	9 ,8	,00389 X	16 ,2	,0044 X
Lake Athabasca .	30 ,4	,02768 X	—	—
Fort Simpson .	—	—	63 ,1	,04182 X

Bearing in mind that Sitka, which differs so widely from Fort Simpson and agrees so nearly with Toronto, is 460 geographical miles distant from the former and 2,250 from the latter,[1] we have here a striking proof how little magnetical phenomena are governed by geographical relations.

There is one other circumstance connected with the disturbance of the declination which I cannot forbear to mention. I mean the remarkable influence of the seasons upon the mean diurnal curve of this quantity; the great augmentation which the principal maximum receives at the time of the equinoxes, and the much lower values which prevail at both the solstices. In the next table are shown the values of the mean disturbance of declination at Philadelphia, Sitka, and Toronto for one year, according to the astronomical seasons.[2] Thus February, March, April, form

[1] Sitka: Latitude 57° 3′; longitude 9^h $2{,}2^m$ W. from Greenwich. It may be necessary to mention that the unifilar magnets at Philadelphia and Sitka were of 2 feet in length; at Toronto, of 14 inches; and at the two northern stations, of 3 inches only. The effect of the dimensions or the inertia of magnets upon the amount of their movements, and upon the mean diurnal curves deduced from those movements, is a subject which requires further investigation (as much in 1883 as it did in 1851).

[2] This arrangement was adopted after actual trial of the more usual division according to meteorological seasons, which did not exhibit the characteristic sought, in such strong contrast.

the group for the vernal equinox, and so on: each quantity is the value of $\sqrt{\frac{\Sigma(\Delta^2)}{N}}$; the whole reduced to arc. (*See* Table XXIX.)

Although it would be improper to unite in one mean seasons so dissimilar as midwinter and midsummer, it will be remarked that they differ much less than might have been expected; and that the difference in the epoch of greatest mean disturbance is very small, in proportion to the difference in the length of the day at these seasons. The means for the year have been already given.

It seems natural to connect this remarkable prevalence of disturbance at the equinoxes with the well-known fact that the aurora borealis is most developed at the same seasons. I do not mean to offer one fact as explaining or accounting directly for the other; but believing the latter to be an entirely atmospheric phenomenon, subject to periodic laws, both diurnal and annual, to suggest that both may be related to a common cause. The magnetical phenomena seem to show that there are two classes of forces, characterised by determining the *equatorial end* of a magnet to the east and west respectively, and that these are severally brought into operation by the presence and absence of the sun above the horizon: when these forces are nearly balanced, owing to the equal length of day and night, or his position near the equator, then disturbances prevail; when either of them greatly preponderates, as happens alternately in winter and summer, there is a less disposition to disturbance. As regards the elements of magnetism, the whole diurnal change then derives its peculiar character principally from the forces proper to the day or night, as the case may be: as regards the aurora, considered as a visible electric discharge, it would seem an inference that the causes producing it are diminished by the same circumstance.

In the foregoing tables, the differences have been summed without regard to their direction or sign. If we sum separately the squares of the differences which have the + and − signs, or which indicate deviations to the east and west of the supposed mean position for the hour, it is found that at every season, and at each of the stations, the maximum of mean disturbance at 9^h or 10^h P.M. is the result of easterly movements. Such is also the case with the maximum at 5 A.M. at the two most northern stations. The westerly means, on the contrary, are the largest during the day; and there are indications of a maximum value under this sign at 6 or 7 A.M., but less regular, and apparently more affected by the seasons than the other.

TABLE XXIX.

Mean disturbance of the declination at three American Stations, arranged to show the effect of the seasons upon this quantity.

Local mean time	EQUINOXES						MEAN OF EQUINOXES			SOLSTICES					
	VERNAL			AUTUMNAL						WINTER			SUMMER		
	Philadel.	Toronto	Sitka	Philadel.	Toronto	Sitka	Philadel.	Toronto	Sitka	Philadel.	Toronto	Sitka	Philadel.	Toronto	Sitka
Midnight	3',20	3',93	6',55	2',13	2',61	3',90	2',72	3',33	5,38	1',23	1',62	4',27	1',83	2',58	2',71
1 a.m.	2,60	3,26	6,49	2,42	3,09	5,49	2,51	3,17	6,02	1,23	1,24	3,83	1,87	2,58	3,28
2	2,67	3,59	4,83	3,22	2,98	3,71	2,96	3,29	4,32	1,09	1,32	3,23	1,52	1,80	4,28
3	2,67	4,21	4,68	3,08	3,01	3,47	2,83	3,65	4,12	1,14	1,31	2,29	1,91	2,13	6,27
4	2,05	3,47	4,75	2,43	3,49	3,26	2,25	3,49	4,07	1,20	1,30	3,03	1,72	2,03	7,35
5	2,19	2,95	4,69	2,82	3,71	3,13	2,57	3,35	4,00	1,26	1,50	2,54	1,91	1,75	3,29
6	2,47	2,73	3,43	2,71	2,93	3,02	2,59	2,83	3,23	1,12	1,27	2,70	1,61	1,94	2,86
7	3,08	3,47	2,91	2,54	4,52	3,03	2,84	4,03	2,97	1,00	0,96	2,94	1,61	1,77	2,61
8	2,21	2,73	2,75	2,63	2,82	3,40	2,43	2,77	3,10	1,30	1,19	2,91	1,52	1,74	2,38
9	2,52	2,02	3,02	2,42	2,30	2,68	2,47	2,16	2,86	1,74	1,87	2,65	1,99	1,55	2,19
10	2,27	2,03	3,51	2,14	2,39	3,60	2,20	2,21	3,55	1,55	1,70	3,00	1,59	2,00	2,29
11	2,19	1,98	2,65	2,32	2,53	3,22	2,26	2,27	2,94	1,42	1,54	3,11	1,67	2,03	2,25
Noon	2,01	1,93	2,59	2,21	2,06	2,67	2,11	2,00	2,63	1,32	1,43	2,73	1,55	1,77	2,39
1 p.m.	1,63	1,67	2,92	1,96	2,18	1,96	1,80	1,94	2,48	1,38	1,45	2,33	1,58	1,77	2,33
2	1,59	1,56	2,44	2,36	2,38	1,89	2,01	2,02	2,17	1,36	1,38	2,24	1,57	1,70	2,28
3	1,66	1,88	2,78	2,27	1,99	2,35	1,99	1,93	2,56	1,36	1,24	2,15	1,69	1,79	2,19
4	1,60	1,59	2,83	2,25	2,07	2,59	1,95	1,85	2,71	1,39	1,20	1,86	1,60	1,65	2,39
5	2,17	2,42	2,66	1,68	2,05	2,62	1,93	2,17	2,65	1,54	1,59	2,00	1,14	1,37	2,70
6	1,82	2,54	3,68	1,91	1,77	2,73	1,87	2,19	3,24	1,38	1,19	1,78	1,28	1,42	2,28
7	2,59	2,03	5,82	1,90	2,25	3,47	2,26	2,14	4,79	1,12	0,99	2,39	1,54	2,02	2,60
8	3,25	4,45	6,63	3,05	4,12	5,06	3,15	4,32	5,90	1,73	1,29	2,41	1,59	2,06	2,35
9	2,73	3,30	4,22	3,39	4,50	6,95	3,08	3,95	5,77	1,87	2,18	2.39	2,17	2,06	2,56
10	3,47	4,47	4,50	2,67	3,05	5,98	3,09	3,81	5 29	1,21	1,30	2,75	2.46	3,62	3,74
11	1,92	3,21	4,01	2,17	3,41	5,00	2,05	3,31	4,54	1,24	1,46	2,59	2,06	2,54	2,16

APPENDIX IV.

BASE ANGLES EMPLOYED, AND ANGLES RECORDED AT STATIONS OF OBSERVATION NOT ALREADY GIVEN IN FULL IN TABLES XII. TO XXV. OF THE 'PHILOSOPHICAL TRANSACTIONS FOR 1846.'

Table XXX.

Fox's Needle B, $q = 0·000113$.

	Th.	2·0 gr.	2·5 gr.	3·0 gr.	3·5 gr.	4·0 gr	Force
		° ′	° ′	° ′	° ′	° ′	
Norway House .	88·0	24 42·1	31 18·6	38 42·5	nil.	56 42·7	—
,, .	69·0	24 5·2	30 58·4	38 39·8	46 17·6	55 36·9	—
Mean . .	78·5	24 23·7	31 8·5	38 41·1	46 17·6	56 9·8	1·8677
Cumberland House	58·0	24 32·9	30 54·7	38 21·5	46 0·3	55 57·2	1·8678
,,	54·0	24 24·5	30 53·2	37 49·5 [1]	46 0·2	56 12·6	1·8684
Great Devil's Port.	74·0	24 45·4	30 57·8	38 56·3	46 16·1	56 30·1	1·8651
Snake Rapid .	52·0	25 15·6 [1]	31 15·9	38 33·2	46 29·1	56 57·3	1·8560
Lake à la Crosse .	69·0	24 45·9	31 5·5	39 29·8	46 31·7	57 4·4	1·8494
,,	64·0	24 44·2	31 7·7	39 26·8	46 33·0	57 0·5	1·8479

Table XXXI.

Fox's Needle C, $q = ·000175$.

	Th.	1·5 gr.	2·0 gr.	2·5 gr.	3·0 gr.	3·5 gr.	Force.
		° ′	° ′	° ′	° ′	° ′	
Fort William .	66·4	19 53·4	27 16·2	34 18·8	42 35·9	— —	—
,,	61·9	19 37·6	26 44·8	34 27·8	42 56·3	— —	—
Mean . .	64·1	19 45·5	27 0·5	34 23·3	42 46·1	— —	1·8601
Fort Coulonge .	57·4	19 52·4	27 11·1	35 2·1	43 31·2	— —	1·8384
Port au Croix .	46·9	20 14·0	27 12·4	34 52·3	43 0·8	— —	1·8323
Rat Portage .	73·0	19 59·5	26 56·6	34 42·5	43 0·9	— —	1·8514
Fort Garry . .	68·9	19 57·1	26 57·9	34 43·3	42 56·3	— —	1·8529
,, . .	60·0	19 53·1	27 1·4	34 28·5	43 0·9	— —	1·8525
L. Winnipeg, 7th .	70·2	19 14·9	26 8·1	33 37·4	41 38·0	— —	1·9080
,, 10th	74·0	19 34·9	26 35·1	34 20·6	42 54·3	— —	1·8721
Norway House .	81·6	19 22·9	26 1·2	34 4·0	42 45·6	— —	1·8737
York Factory .	77·9	18 54·1	25 57·3	32 48·1	40 51·3	— —	1·9392 [2]
Windy Lake . .	69·5	20 30·5	26 38·6	35 18·1	42 45·8	— —	1·8741

[1] Rejected. These values differ slightly from those in the text, which were inadvertently reduced with the former base value for Norway House, viz. 1·873.

[2] York Factory. This value of the force is at variance with all the other determinations, and probably due to some impediment to the free motion of the needle.

Table XXXI.—(*continued*).

	Th.	1·5 gr.	2·0 gr.	2·5 gr.	3·0 gr.	3·5 gr.	Force
Readjustment.		° ′	° ′	° ′	° ′	° ′	
Norway House .	56·5	19 25·7	26 56·4	34 8·1	42 28·0	52 34·1	—
,,	57·5	19 38·7	26 52·6	34 16·0	42 50·6	52 31·8	—
,,	—	—	—	—	42 31·4	—	—
,,	—	—	—	—	42 58·6	—	—
Mean . .	57·0	19 32·2	26 54·5	34 12·0	42 42·1	52 33·0	1·8677
Old Norway House	64·2	19 47·3	26 41·2	34 46·2	42 30·9	52 34·0	1·8642
L. Winnipeg, 14th	64·9	19 56·2	26 53·1	34 11·0	43 10·6	—	1·8576
Grand Rapid .	66·0	19 56·4	27 3·8	34 3·3	42 39·4	—	1·8608
Cross Lake . .	62·6	19 47·9	26 42·7	35 3·8	42 52·5	—	1·8552
Cumberland House	66·3	20 25·6[1]	27 7·8	34 47·8	43 33·6	52 49·5	1·8510
,,	52·4	19 24·4	26 54·6	33 47·5	43 11·1	52 35·8	1·8689
Beaver Lake .	63·7	19 34·5	27 50·5	34 33·6	44 10·6	52 26·3	1·8398
P. des Epinettes .	56·1	19 25·8	27 13·3	34 35·6	43 16·3	—	1·8549
Frog Portage .	59·1	19 57·5	27 33·6	34 3·5	43 40·7	—	1·8462
Little Rock P. .	67·6	18 14·2	25 19·5	31 45·3	39 59·6	48 25·6	1·9842
Pine Portage .	62·6	19 54·5	26 36·9	32 44·2[1]	43 35·5	53 39·8	1·8519
Snake Rapid .	54·6	19 31·3	26 38·1	33 44·9	43 38·3	53 23·9	1·8641
The stations following are rejected for loss of magnetism.							
Port Sonnante .	56·0	19 51·9	27 49·9	35 40·9	45 13·3	55 12·7	1·8070
Isle à la Crosse .	51·1	20 1·0	28 13·0	35 5·0	45 2·7	54 31·7	1·7999
,,	73·1	—	28 18·1	35 50·5	44 52·4	54 29·0	1·7962
Buffalo Lake .	51·3	20 8·8	28 10·0	35 4·4	44 29·0	54 20·5	1·7861
River de la Loche .	67·9	20 28·1	28 45·4	35 57·7	46 21·7	55 55·6	1·8021
Port de la Loche .	57·0	20 3·6	28 1·6	35 35·5	46 24·0	55 16·5	1·7954
Clearwater River .	42·7	20 29·7	28 1·3	35 15·5	45 5·1	54 21·7	1·7992
Pierre au Calumet	64·4	19 52·3	27 32·2	34 12·3	43 18·9	53 25·7	1·8440
Pointe Brulée .	43·0	20 25·1	27 41·7	34 6·8	43 49·9	53 26·0	1·8184
Fort Chipewyan .	44·3	20 40·1	29 0·0	35 35·0	43 42·5	57 38·9	1·7769
,,	41·1	20 27·1	28 1·7	35 35·7	43 34·8	57 26·8	1·7966

Table XXXII.

Fox's Needle A, as employed in 1844, and referred to Fort Chipewyan as base.

1844		Th.	2·5 gr.	3·0 gr.	3·5 gr.	4·0 gr.	5·0 gr.	Force
		°	° ′	° ′	° ′	° ′	° ′	
July 3	Fort Chipewyan .	53·0	27 32·2	34 19·3	40 24·0	48 41·7	56 56·2	1·8346
,, 12	Fort Vermilion .	69·0	27 20·1	33 51·3	40 7·1	47 44·8	56 10·7	1·8642
,, 23	Fort Dunvegan .	54·9	27 6·6	33 47·8	40 15·5	47 57·1	56 3·4	1·8565
Aug. 19	Edmonton . .	38·1	27 19·7	33 47·2	40 3·0	47 21·5	55 26·0	1·8558
,, 30	Cumberland House	61·6	26 39·5	32 56·8	38 59·0	46 24·7	54 6·2	1·9035

1 These angles are rejected.

2 This value being considerably in excess of the truth, as established by the whole body of observations, has been disregarded. On the supposition that the free movement of the needle was prevented by rust on the axle, I changed it and tried others, but their performance being very unsatisfactory, the same axle partially repolished was replaced. Hence the impossibility of referring the observations of 1844 before August 30, to Toronto, or those taken subsequently to Athabasca. The series ends here.

TABLE XXXIII.

Fox's Needle C as employed in 1844 and referred to Fort Chipewyan as base.

1844		Th.	1·5 gr.	2·0 gr.	2·5 gr.	3·0 gr.	3·5 gr.	Force
			° ′	° ′	° ′	° ′	° ′	
July 3	Fort Chipewyan .	59·1	20 48·6	28 40·8	36 21·7	46 18·4	57 1·9	1·8346
„ 12	Fort Vermilion .	48·7	20 44·9	28 55·6	36 14·4	46 2·3	56 39·8	1·8365
„ 23	Fort Dunvegan .	75·5	20 30·5	28 39·6	36 29·7	46 26·4	57 0·3	1·8450
Aug. 19	Edmonton . .	48·4	20 36·8	28 28·7	36 35·4	46 4·5	56 56·5	1·8391
„ 30	Cumberland House	58·3	20 19·1	28 19·1	35 42·8	45 43·4	55 29·6	1·8646

The unsatisfactory condition both needles, A and C, were in by this time, accounts for a consistent difference between their results in the last two tables, C always giving slightly lower values than A; but, as pointed out in the text, pp. 35, 36, they concur with the absolute determinations in proving the values of the force in this region, as formerly published, to have been about 0·04 on the relative scale, or 0·30 on the absolute scale, too low.

Both needles were observed again at Norway House on September 7, and at Toronto on December 14, 1844, but not at any intermediate points. The result of this comparison was:—

	Force at Norway House.
Needle A . . .	1·8554
„ C . . .	1·8669
Mean . .	1·8611, or 14·086

which is rather less than the value given in the text, p. 104, viz. 1·8677, or 14·136, but in good general agreement with it.

The fitness of either Toronto, Fort William, Norway House, or Fort Chipewyan, to be taken as base stations, each of them being situated on the northern margin of a large fresh-water lake, is a question which did not engage any attention at the dates of these observations. The choice was dictated by convenience alone. There are some reasons for thinking such a geographical position exceptionally liable to abnormal values of one or other element; this is very observable at Fort Chipewyan. A greater multiplication of observations is necessary to determine the local errors which remain, with other questions, for a more deliberate investigation hereafter.

STATIONS.

A LIST OF STATIONS OF OBSERVATION, AND OF OTHER PLACES NAMED, ARRANGED ALPHABETICALLY.

The qualifications—Fort, House, Portage, Lake, River—are generally disregarded. The place will be found by its distinguishing appellation. Thus: Portage des Deux Rivières under D; Grand Rapid under G.

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[To precede Magnetic Chart of North-Western America.]

MAGNETIC CHARTS.

THE subjoined Tables contain the data for portions of the lines laid down on the accompanying maps, which are dependent upon observations subsequent to the writer's magnetic survey, and not given in the text; but belong to the same geographical region and the same general epoch.

I.

Observations of the late Captain R. W. Haig, R.A., in British Columbia, 1858–1861, '*Phil. Trans.*' 1864. *They have been reduced to the date* 1844.

No.	Lat.	Long.	Dip		Force		Declination		
			As Observed	Corr. +	As Observed	Corr. +	As Observed	Corr −	
	° ′	° ′	° ′	′	φ		° ′	′	
1	48 26	123 27	71 34	10·5	13·103	0 102	21 58 E.	28	
2	49 1	122 12	72 22	11·0	13·366	,,	21 30	28	
3	47 7	122 25	70 40	10·4	13·116	,,	21 23	30	
4	49 2	122 0	72 4	10·4	13·285	,,	21 37	27	
5	49 2	121 23	72 31	10·3	13·180	,,	—	—	
6	45 38	122 28	69 17	9·8	13·052	,,	20 5	27	
7	45 35	120 49	69 42	9·8	13·151	,,	20 37	27	
8	45 40	120 49	70 5	9·8	13·003	,,	18 44	27	*Rejected.*
9	49 10	120 0	72 37	9·6	13·226	,,	22 10	27	
10	49 7	120 0	—	—	—	—	21 50	27	
11	49 0	120 0	72 27	9·5	13·321	,,	22 44	27	
12	49 0	119 24	—	—	—	—	22 14	27	
13	49 0	118 28	72 49	9·1	13·272	,,	20 17	25	
14	48 40	118 5	72 42	9·1	13·397	,,	21 40	25	
15	48 0	117 45	72 4	9·0	13·343	,,	21 28	25	
16	48 9	116 44	72 35	9·0	13·370	,,	21 16	25	
17	48 22	116 28	72 46	9·0	13·391	,	22 51	25	
18	48 41	116 19	73 8	9·0	13·469	,,	22 11	25	
19	48 22	115 21	72 48	9·0	13·435	,,	22 16	25	
20	48 40	115 17	73 7	9·0	13·443	,,	23 24	25	
21	48 57	115 8	73 23	9·0	13·477	,,	—	—	
22	49 0	114 45	73 31	9·0	13·497	,,	23 52	25	
23	49 1	114 4	73 43	9·0	13·587	,,	23 12	25	

II.

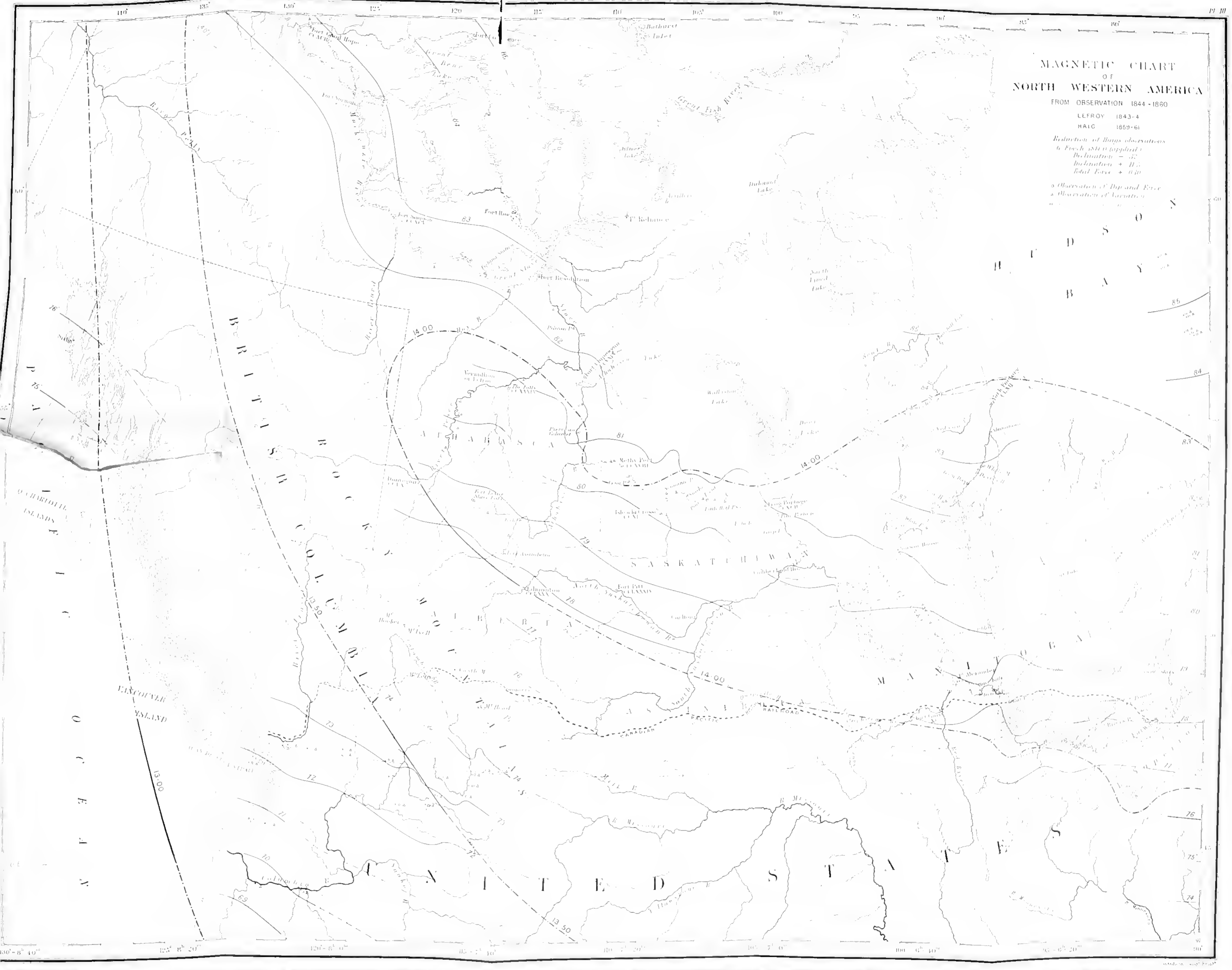
Observations in Hudson's Bay by Captain T. E. L. Moore, R.N., taken in the course of a voyage in the Hudson's Bay Company's ship to Moose Factory in 1846 (Sabine in 'Phil. Trans.' 1872). No correction has been applied for two and a half years' difference of date.

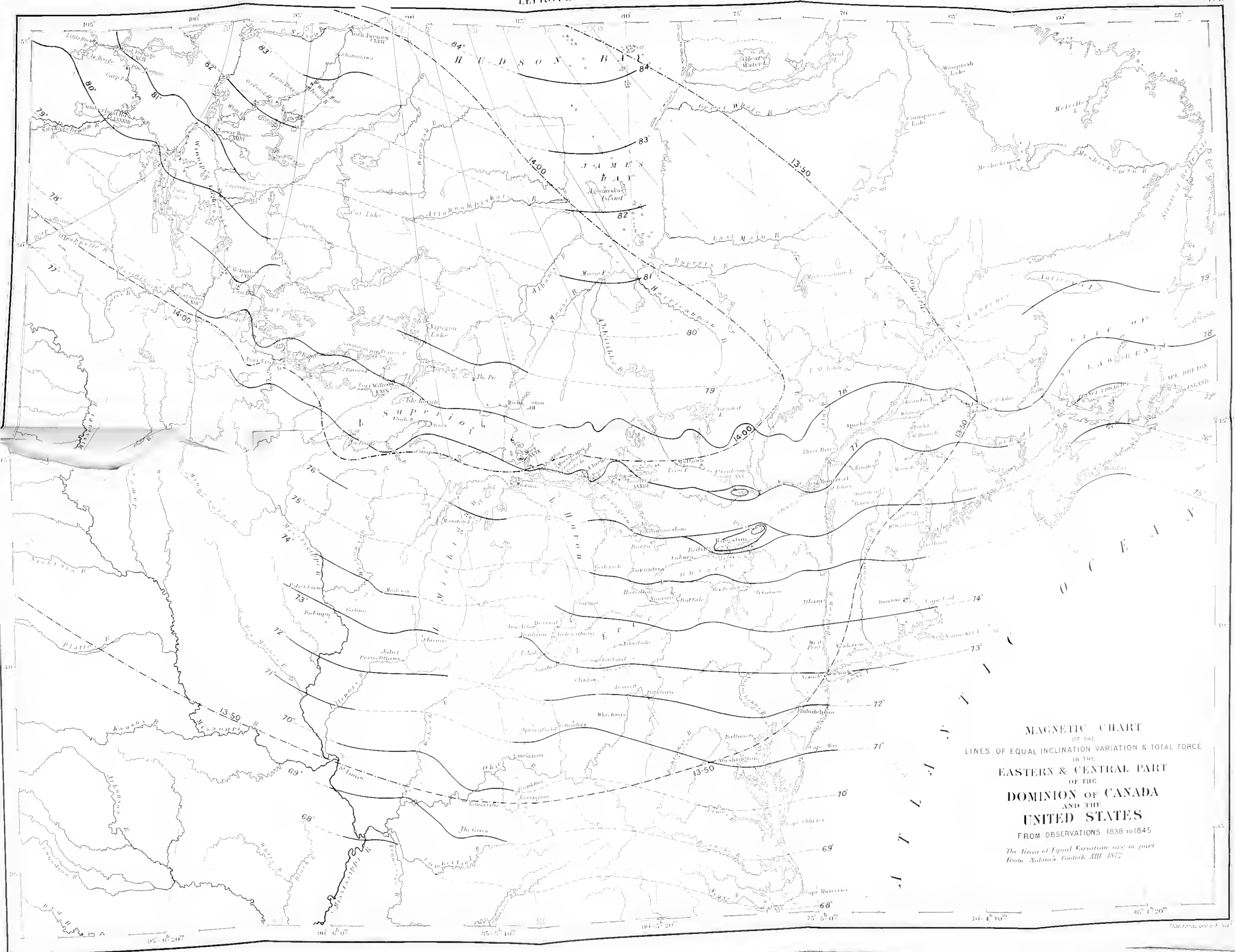
Lat.		Long.		Dip		Force	Declination		
°	′	°	′	°	′	φ	°	′	
63	17	78	55	86	35	13·55	58	15 W.	At Sea
62	20	81	12	86	7	—		—	„
62	10	80	10	87	1	13·36		—	„
61	7	82	50	87	0	13·19		—	„
60	50	83	3		—	—	30	35	„
60	45	82	45	86	41	13·58		—	„
60	26	82	8	85	20	13·57	34	0	„
60	25	82	42	86	36	13·22		—	„
60	20	81	12	86	7	—		—	„
60	10	80	10	87	1	13·36		—	„
59	11	82	45	86	30	13·64		—	„
58	53	82	52	85	48	—	20	52	„
57	32	82	37	85	15	13·28	16	15	„
57	15	82	53	84	34	13·53	15	57	„
57	15	82	33	84	30	13·59	15	57	„
57	9	82	42	84	36	—	17	16	„
57	4	82	37	84	31	—		—	„
56	40	81	57	84	42	13·55		—	„
56	29	82	32		—	—	15	48	„
56	24	81	50	84	10	—		—	„
55	29	82	24	83	48	13·26		—	„
55	25	82	14	84	0	13·59	11	53	„
54	43	81	32	83	47	13·84	13	30	„
53	57	81	30	83	2	13·79		—	„
53	42	81	9		—	13·89	12	48	„
53	24	81	6	82	20	—		—	„
53	10	80	48		—	—	12	30	„
52	20	80	17	81	49	—		—	„
51	15	80	56	81	30	14·12	12	40	Moose Factory.
51	32	80	34	80	59	—	10	41	At Sea
51	17	80	26		—	—	12	40	„
51	8	80	41	81	2	14·07	10	55	On Shore

A few observations by Dr. Rae are also inserted, and here note corrections to Table XVI. p. 116: Churchill Lat. 58° 43′ 50″. Knapps Bay Dip 86° 18′·8. The next observation, by Rae's Journal, was on July 18, and north of Knapps Bay. *Dele.* „ 2.

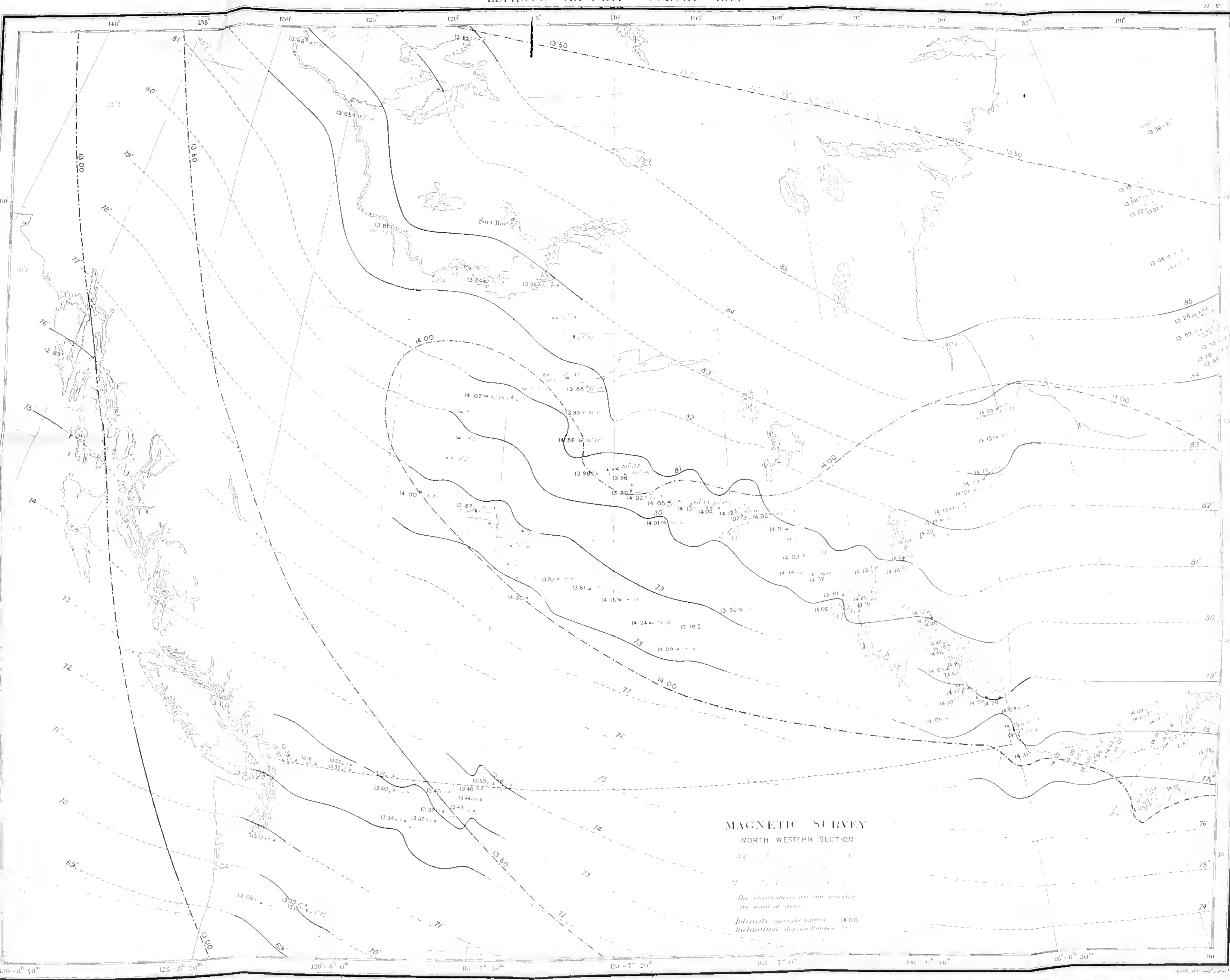
III.

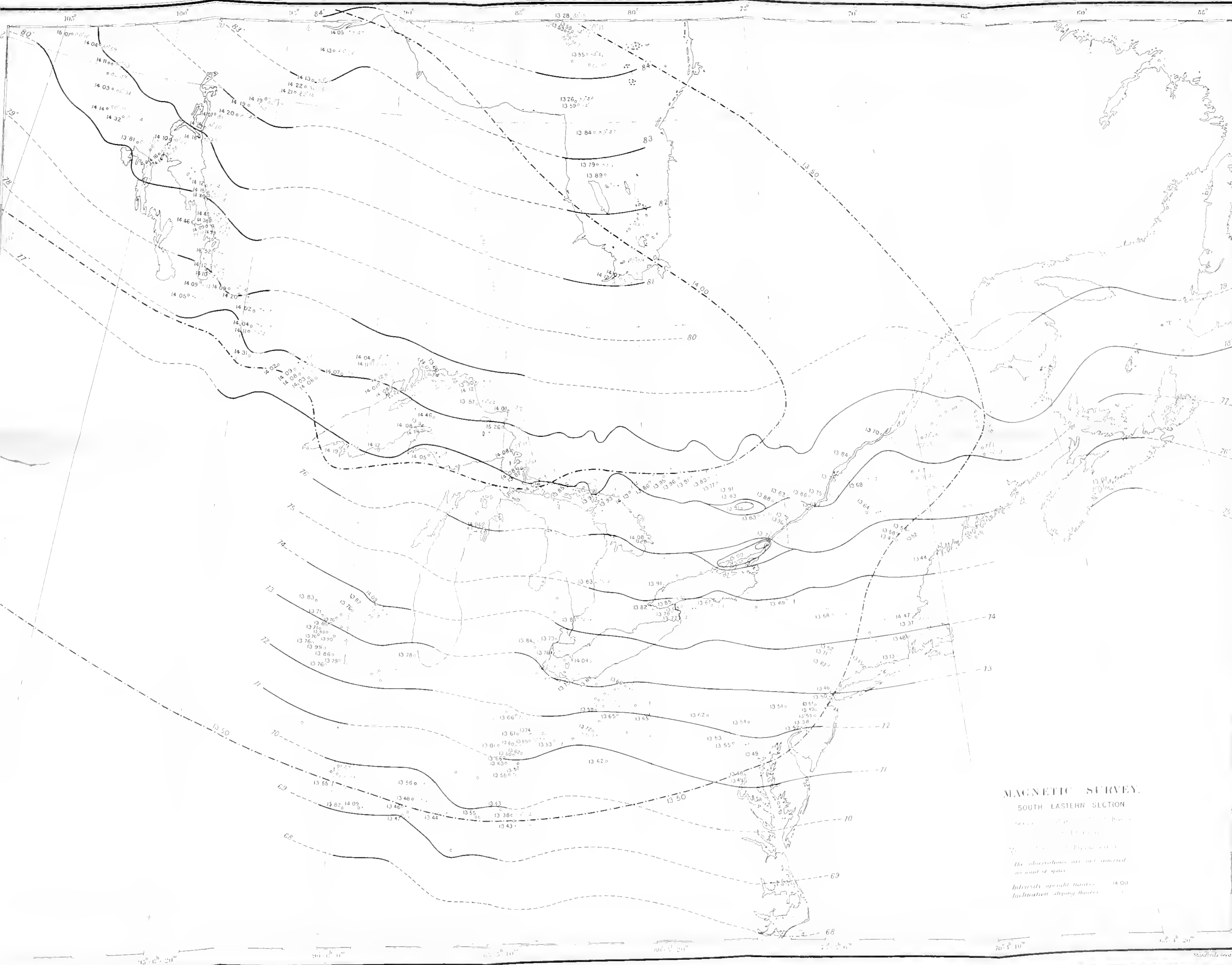
About 180 stations are marked in the United States, and a few names inserted to assist their identification; but as the observations were given in full by Sabine in 1846, it appears unnecessary to repeat them. The intensities were chiefly determined by Dr. Locke between the years 1838 and 1845; the Dips observed by Locke, Loomis, Graham, and others in the same years.


Pl. III
MAGNETIC CHART
OF
NORTH WESTERN AMERICA
FROM OBSERVATION 1844 - 1860
LEFROY 1843-4
HAIG 1859-61
HUDSON BAY
ATHABASCA
SASKATCHEWAN
MANITOBA
BRITISH COLUMBIA
ROCKY MOUNTAINS
ALBERTA
UNITED STATES
PACIFIC OCEAN
VANCOUVER ISLAND
Q. CHARLOTTE ISLANDS
Great Bear Lake
Great Slave Lake
Fort Resolution
Ft. Reliance
Fort Rae
Fort Simpson
Fort Good Hope
Bathurst Inlet
Great Fish River
Fort Chipewyan
Athabasca Lake
Fort Edmonton
Fort Pitt
North Saskatchewan R.
South Saskatchewan R.
York Factory
CANADIAN PACIFIC RAILROAD
14.00
13.50
13.00


MAGNETIC CHART
OF THE
LINES OF EQUAL INCLINATION VARIATION & TOTAL FORCE
IN THE
EASTERN & CENTRAL PART
OF THE
DOMINION OF CANADA
AND THE
UNITED STATES
FROM OBSERVATIONS 1838 TO 1845
The lines of Equal Variation are in part
from Sabine's Contrib. XIII 1872
HUDSON BAY
JAMES BAY
ATLANTIC OCEAN
L. Superior
L. Huron
L. Michigan
L. Erie
L. Ontario
Gulf of St. Lawrence
14.00
13.50

LEFROY'S MAGNETIC SURVEY 1844.




MAGNETIC SURVEY.
SOUTH EASTERN SECTION